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THE NASTRAN USER'S MANUAL

(Level 15.0)

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Editor

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FOREWORD

For many decades the art of structural analysis remained essentially stagnant, not because of lack of theoretical understanding but because of limitations on capability for numerical computation. The analyst was constrained to apply approximate continuum solutions of the equations of elasticity to his structure which yield, for the most part, average stress and strain distributions not taking account of localized structural features. Fortunately, most aircraft could be approximated by a collection of beam-like one-dimensional structures--that is, structures where state of deformation could be adequately described by a set of functions of a single space coordinate. But, spacecraft structures and very high speed aircraft began to depart appreciably from such idealizations. Structural analysts began to adapt theory to aircraft structures viewed as an assemblage of a finite number of elastic components over 20 years ago. In one of the first papers on the subject, Levy in 1947 isolated each component, placed it in static equilibrium, and regarded the internal forces as the unknown quantities. The principle of minimum strain energy was applied to determine the correct internal force distribution. Subsequent papers by Schuerch, Levy, Turner, Clough, Martin and others took the deformations of the various discrete components of the structure as the unknown quantities, instead of the forces on the components. The correct deformation pattern was obtained by applying the principle of minimum potential energy. In all of these applications, matrix formulations were developed early as a means of organizing the bookkeeping. Numerical solutions were, for the most part, reduced to the processes of addition, subtraction, multiplication, inversion and finding the characteristic roots and vectors of matrices. But the analyst was limited at first by the desk calculator. The inversion of ten by ten matrices by Crout's or an equivalent method was a formidable exercise. It is no wonder that the earliest users of digital computers in the aircraft companies were the Structures and Dynamics Divisions of the Engineering Department. It was indeed fortunate that the birth of the digital computer came when it did.

But the development of software for structural analysis became a separated and individualistic activity with little or no coordination. There grew a tendency toward proprietary secrecy. Little compatability was developed among the various structural analysis programs throughout the country. The present program, called NASTRAN, is an attempt to bring together the best features of the state

of the art into a single program for the analysis of large complex structures. The result is an exemplary beginning. It will not satisfy every requirement at first. But, it forms a framework for an enormous step forward in the development of a common base. The NASA staff and contractors who conceived of and took part in this important new development are to be commended for their foresight and skill.

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INTRODUCTION TO THE NASTRAN PROGRAM

The acronym NASTRAN is formed from NAsa STRuctural ANalysis. NASTRAN is a general purpose digital computer program for the analysis of large complex structures and has its origins in the research councils of NASA. During the annual review of NASA's research program in the area of structural dynamics by Douglas Michel of Headquarters in January 1964, it became apparent that there was considerable effort by many of the Centers to develop computer programs for structural analysis, designed to meet each of the Centers' particular needs. It was suggested that perhaps a single program could meet all their needs. The Office of Advanced Research and Technology appointed a committee with representation from eight NASA Centers to study this possibility. Thus formed, the AD HOC GROUP ON COMPUTER METHODS IN STRUCTURAL ANALYSIS was constituted as follows:

Ames Research Center	Richard M. Beam
	Perry P. Polentz
Flight Research Center	Richard J. Rosecrans
Goddard Space Flight Center	Thomas G. Butler
	Peter A. Smidinger
Jet Propulsion Laboratory	Marshall E. Alper
	Robert M. Bamford
Langley Research Center	Herbert J. Cunningham
Lewis Research Center	William C. Scott
	James D. McAleese
Manned Spacecraft Center	C. Thomas Modlin, Jr.
	William W. Renegar
Marshall Space Flight Center	Robert L. McComas

Adjoint Member: James Johnson from Wright Patterson Air Force Base

Chairman: Thomas G. Butler

After six months of investigation, the Ad Hoc Group reported to Headquarters that there was no digital program in existence which had broad, uniform capabilities

in the three interdependent disciplines of analytical mechanics, numerical methods, and computer programming. The Group did observe that there was considerable capability dispersed throughout the aerospace industry which had not been collected into a single program. They found also that there was a tendency toward proprietary secrecy which inhibited exchange of information. Communication was further hindered by the lack of compatibility between any two companies' structural analysis programs. The Ad Hoc Group recommended that NASA sponsor an entirely new program aimed at bringing together all the best in the state-of-the-arts. NASA is indebted to many people, but especially to these individuals in the several companies for assisting the Ad Hoc Group during its investigations:

M. John Turner of Boeing Seattle
W. J. Crichlaw of Lockheed Burbank
Paul H. Denke of Douglas Long Beach
Robert J. Melosh of Philco Western Development Labs
Richard H. Gallagher of Bell of Buffalo
P. L. Marshall of North American Columbus
Stanley Kaufman of Martin Baltimore

Headquarters endorsed the recommendations of the Ad Hoc Group and commissioned them to draw up a set of specifications. Fortunately, the papers from the first Wright Field Conference, "On Matrix Methods in Structural Analysis", were at hand to consult. The objectives of the specifications are now being achieved:

Combine the best of the state-of-the-arts in 3 disciplines.
Incorporate both the Force and the Displacement approaches of finite elements.
Organize to be General Purpose.
Embody large three dimensional structural capability.
Establish computer independence.
Provide for modification without cascading effects.
Build in the maximum of user convenience.
Document all aspects to gain maximum visibility.

The contract to implement the NASTRAN specifications was awarded to Computer Sciences Corporation (CSC) with MacNeal Schwendler, Martin Baltimore, and later

Bell Aerosystems Company as sub-contractors. The team that CSC assembled was one that identified strongly with the project. The designers were Dr. Richard H. MacNeal, Dr. Paul R. Peabody, Prof. C. W. McCormick, Mr. Stanley Kaufman, Mr. Thomas L. Clark, and Mr. David B. Hall. Except for Dr. Peabody, all of the designers were also involved with the implementation. The team of computer programmers was led by Mr. Keith H. Redner. The other principal members of the implementation team were Richard S. Pyle, Carl Hennrich, Steven E. Wall, Frank J. Douglas, Howard Dielmann, and David Herting. The quality of the NASTRAN program and its documentation is testimony to the purposefulness with which this implementation team applied themselves. We in NASA extend our sincere gratitude to all these men. This team has often exceeded the state-of-the-arts guidelines that were set down. A few examples are: the Segment File Allocator, the General Input/Output Module, matrix decomposition with active columns, the inclusion of scalar nonlinearities in control system dynamics, the generality in the plot module, and the development of the self-contained "inverse power with shifts" module for eigenvalue extraction. The overall design of the program has set a new standard for general purpose programs of any discipline. The framework used in NASTRAN can be disassociated from elastic structures and be applied to other disciplines, because there are no semantic implications in the executive operations. The program abounds in service code, that threads through every step of the problem physics, providing convenience to the analyst.

The NASTRAN Project personnel at Goddard Space Flight Center also strongly identified with the program. They are: Richard D. McConnell, William R. Case, James B. Mason, William L. Cook, and Edward F. Puccinelli. Their unflagging efforts in debugging and editing have been indispensable.

Many policy decisions had to be made as to the content of NASTRAN. The total framework of the program was considered to be the most important; i.e., commensurate large problem capability from basic statics for general conditions to advanced dynamics; with an executive system that could manage problems unbounded by core; was compact in its space requirements; could restart problems; could operate efficiently over different computers; and still be maintainable. This is

a costly venture and one could not expect the program to be complete in all its details. We wanted it to be complete in its principals and essentials. Consequently, some aspects were of necessity postponed.

It was decided that only basic finite elements would be included to deal with one and two dimensional elastic relationships such as beams, plates and axisymmetric shells. Economy of running time for the state-of-the-arts elements was a determining factor in their selection More sophisticated and new elements have appeared in the state-of-the-art since the inception of this program, which can easily be incorporated.

An interesting type of decision erupted as a result of third generation computers. The relative costs of input-output and sorting operations had to be compared against regeneration whenever calculated data was used subsequently. In the majority of instances, the decision was made in favor of regeneration because the quantity of input data (usually from single precision engineering sources) was small; the compute time for regeneration was usually less than the associated input-output time; the quantity of generated data was usually orders of magnitude greater (and in double precision) compared to the engineering source data, and the read and write operations and subsequent logical operations for sorting and merging were very time-consuming.

In the matter of eigenvalues, the range of demands is such that no single current routine will satisfy all requirements. Two principal types of routines were decided upon; those that transform the whole matrix for simultaneous determination of roots and those that perform separate operations on the original matrix for each root extracted. The former is more efficient for a large number of roots, while the latter type is more efficient for a few roots of large matrices. Solution of complex matrices is performed only by the root tracking schemes and not by transformation methods, because existing transformation techniques for complex matrices are too expensive.

There was advice from many sources that the time was not right for a large general purpose program, because the flux in hardware and software was too great. The fear was that the endeavor would result in a program which would be obsolete

before it was finished. The rapidly changing computer technology had the opposite effect on the NASTRAN Project. The situation forced men to think more generally so that viability could be preserved in spanning the gap between second and third generation machines and anticipating the impact of fourth generation computers. The decision was made to write a single program in FORTRAN IV with some exceptional areas to be written in assembly language. FORTRAN IV version 13 in its various forms on different computers seems to have stabilized out as a language that will have currency for a reasonable time in the future. More than 99% of the program is written in this FORTRAN. The program is modular so that updating is a matter of revamping material within a module without modifying its external appearances.

The task of writing a program that performed efficiently on different manufacturers' computers forced many decisions. It was very tempting to capitulate to the disparities amongst the computers and resign ourselves to the rationale that for each computer, there would be a different version of NASTRAN. Fortunately, the decision was made to create just one version of NASTRAN. In some respects, this decision might have been viewed by some as having a corroding effect on the program. The conception derives from the condition that code was not written simultaneously for all computers. It was written first for the "development computer - the IBM Direct Coupled 7094/7040"; subsequently, it was tried on the others. Failures of programming designs on subsequent machines decreased the set of admissable procedures that remained in the intersection of the languages of all required computers. Fortunately, the remaining subset is sufficiently versatile, that it was possible to achieve commonality without becoming primitive. To date, the computers for which NASTRAN has been adopted are: IBM 7094/7044, UNIVAC 1108, CDC6600, and IBM 360. One serious lack of common intersection was in core management. NASTRAN is so large that logic demands that it be designed in multiple links horizontally and in many levels of overlay vertically with the additional ability to manage core dynamically. When it was found that Control Data did not provide for this type of core management, the decision was made to write a loader to replace that which Control Data offered with their SCOPE 3 operating system. The basic set of NASTRAN functional modules

is thus preserved as a single unit for all computers. Problems in trouble-shooting and maintenance are thus confined to a single source. This decision affected the compatibility with time sharing of the IBM TSS type. An entirely different version of NASTRAN would be required to adapt the program to the TSS system. Well-founded doubts also persist about its eventual execution efficiency. Consequently, NASTRAN is not designed to operate under a time sharing system.

Originally, a number of conveniences were going to be built into NASTRAN. As design evolved, the number of convenience nominees expanded. It was finally decided that conveniences having to do with the preparation of input data in NASTRAN format were properly external to the program. All such routines could be classified as NASTRAN auxiliary programs. Examples of this classification are: the automatic generation of grid points and elastic elements for an analytically known geometry, the computation of equation ordering for the minimization of the bandwidth of non zero elements in the stiffness matrix, or the formatting of experimental data as input to the General Element. Hundreds of such programs will probably be written and their lives will probably be short. For these reasons, they are considered external auxiliaries. Circulation of announcements about such programs will be made to users of the program, so they can be obtained easily.

Hopefully, the framework that has been built has also been sufficiently well fleshed out that it will serve a sizable portion of the large problems in the structural analysis community currently. It is intended that new capability be added or outdated capability be replaced by augmenting or replacing modules. An entire chapter in the Programmer's Manual has been devoted to the topic of Modifications and Additions in anticipation of serving this particular activity. The traffic in the development of new and increasingly versatile elastic modules is expected to be the most active. As analysts increase their use of the program, their detailed needs will become better defined with the consequent result that the traffic in "convenience code" will also be expected to increase. It is our strong desire that all such new features be called to the attention of the NASTRAN Project so that these ideas and routines can be disseminated to a broad audience.

Thomas G. Butler
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Goddard Space Flight Center
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EDITORS PREFACE TO THE NASTRAN USER'S MANUAL

The User's Manual is one of three manuals that constitute the documentation for NASTRAN, the other two being the Theoretical Manual and the Programmer's Manual. Although the User's Manual contains all of the information that is directly associated with the solution of problems with NASTRAN, the user will find it desirable to refer to the other manuals for assistance in the solution of specific user problems.

The Theoretical Manual is an excellent introduction to NASTRAN for those who are using NASTRAN for the first time. The User's Manual is restricted to those items related to the use of NASTRAN that are independent of the computing system being used. Computer dependent matters, such as operating system control cards, are treated in Section 5 of the Programmer's Manual.

NASTRAN uses a finite element structural model, wherein the distributed physical properties of a structure are represented by a finite number of structural elements which are interconnected at a finite number of grid points, to which loads are applied and for which displacements are calculated. The procedures for defining and loading a structural model are described in Section 1. This section contains a functional reference for every card that is used for structural modeling.

The NASTRAN Data Deck, including the details for each of the data cards, is described in Section 2. This section also discusses the NASTRAN control cards that are associated with the use of the program.

The initial version of NASTRAN contains twelve separate problem solution sequences, called rigid formats. Each of these rigid formats is associated with the solution of problems for a particular type of static or dynamic analysis. Section 3 contains a general description of rigid format procedures, along with specific instructions for the use of each rigid format.

The procedures for using the NASTRAN plotting capability are described in Section 4. Both deformed and undeformed plots of the structural model are available. Response curves are also available for transient response and frequency response analyses.

In addition to the rigid format procedures, the user may choose to write his own Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The rules governing the creation of DMAP programs are described in Section 5.

The NASTRAN diagnostic messages are documented and explained in Section 6. The NASTRAN Dictionary, in Section 7, contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms.

Sample problems are not included in the User's Manual. However, a set of twenty demonstration problems, at least one for each of the twelve rigid formats, are described in an auxiliary publication entitled the NASTRAN Demonstration Problem Manual. The data decks are available on tape, in the form of a User's Master File, for each of the computers on which NASTRAN has been implemented. Samples of the printer output and of structure plots and response plots can be obtained by executing these demonstration problems.

A great many people have been associated with the development of NASTRAN and all have had some influence on the preparation of the User's Manual. Most of the members of both the programming staff and engineering staff have made some direct contributions to the User's Manual. Particular recognition is due Mr. Carl W. Hennrich who had direct responsibility for the collection and preparation of much of the material in the Manual. In addition, Mr Thomas G. Butler, the NASTRAN Project Manager, and his devoted group at Goddard Space Flight Center, should be commended for their painstaking and constructive review of the User's Manual.

Caleb W. McCormick

August, 1969

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*6.2-23	4/1/73	7.1-5	6/1/72	*7.1-32	4/1/73
6.2-23a	6/1/72	*7.1-6	4/1/73	*7.1-33	4/1/73
6.2-24	3/1/71	*7.1-7	4/1/73	*7.1-34	4/1/73
6.2-25	6/1/72	*7.1-7a	4/1/73	*7.1-34a	4/1/73
6.2-25a	6/1/72	7.1-8	6/1/72	*7.1-35	4/1/73
*6.2-26	4/1/73	*7.1-9	4/1/73	7.1-36	6/1/72
6.2-26a	6/1/72	**7.1-9a	4/1/73	*7.1-37	4/1/73
6.2-27	3/1/71	7.1-10	6/1/72	*7.1-38	4/1/73
*6.2-28	4/1/73	*7.1-11	4/1/73	*7.1-39	4/1/73
6.2-28a	6/1/72	7.1-12	6/1/71	*7.1-40	4/1/73
*6.2-28b	4/1/73	7.1-13	3/1/71	7.1-41	6/1/72
*6.2-28c	4/1/73	7.1-13a	3/1/71	*7.1-42	4/1/73
**6.2-28d	4/1/73	7.1-14	3/1/70	7.1-43	7/1/70
6.2-29	3/1/71	*7.1-15	4/1/73	7.1-44	7/1/70
*6.2-30	4/1/73	**7.1-15a	4/1/73	7.1-45	
6.2-31	6/1/72	*7.1-16	4/1/73	7.1-46	
6.2-32	3/1/71	7.1-17	9/1/70		

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STRUCTURAL MODELING

1.1 INTRODUCTION

NASTRAN embodies a lumped element approach, wherein the distributed physical properties of a structure are represented by a model consisting of a finite number of idealized substructures or elements that are interconnected at a finite number of grid points, to which loads are applied. All input and output data pertain to the idealized structural model. The major steps in the definition and loading of a structural model are indicated in Figure 1.

As indicated in Figure 1, the grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points.

Two general types of grid points are used in defining the structural model. They are:

1. Geometric grid point - a point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.

2. Scalar point - a point in vector space at which one degree of freedom is defined. Scalar points can be coupled to geometric grid points by means of scalar elements and by constraint relationships.

The structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution and some types of applied loads. In static analysis by the displacement method, stiffness properties are input exclusively by means of structural elements. Mass properties (used in the generation of gravity and inertia loads) are input either as properties of structural elements or as properties of grid points. In dynamic analysis, mass, damping, and stiffness properties may be input either as the properties of structural elements or as the properties of grid points (direct input matrices).

Structural elements are defined on connection cards by referencing grid points, as indicated on Figure 1. In a few cases, all of the information required to generate the structural matrices for the element is given on the connection card. In most cases the connection card refers to a property card, on which the cross-sectional properties of the element are given. The property card in turn refers to a material card which gives the material properties. If some of the material properties are stress dependent or temperature dependent, a further reference is made to tables for this information.

Various kinds of constraints can be applied to the grid points. Single-point constraints are used to specify boundary conditions, including enforced displacements of grid points.

Multipoint constraints are used to specify a linear relationship among selected degrees of freedom, including the definition of infinitely rigid elements. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in dynamic analysis. Free-body supports are used to remove stress-free motions in static analysis and to evaluate the free-body inertia properties of the structural model.

Static loads may be applied to the structural model by concentrated loads at grid points, pressure loads on surfaces, or indirectly, by means of the mass and thermal expansion properties of structural elements are enforced deformations of one-dimensional structural elements. Due to the great variety of possible sources for dynamic loading, only general forms of loads are provided to the user in dynamic analysis.

The following sections describe the general procedures for defining structural models. Detailed instructions for each of the bulk data cards and case control cards are given in Section 2. Additional information on the case control cards and use of parameters is given for each rigid format in Section 3.

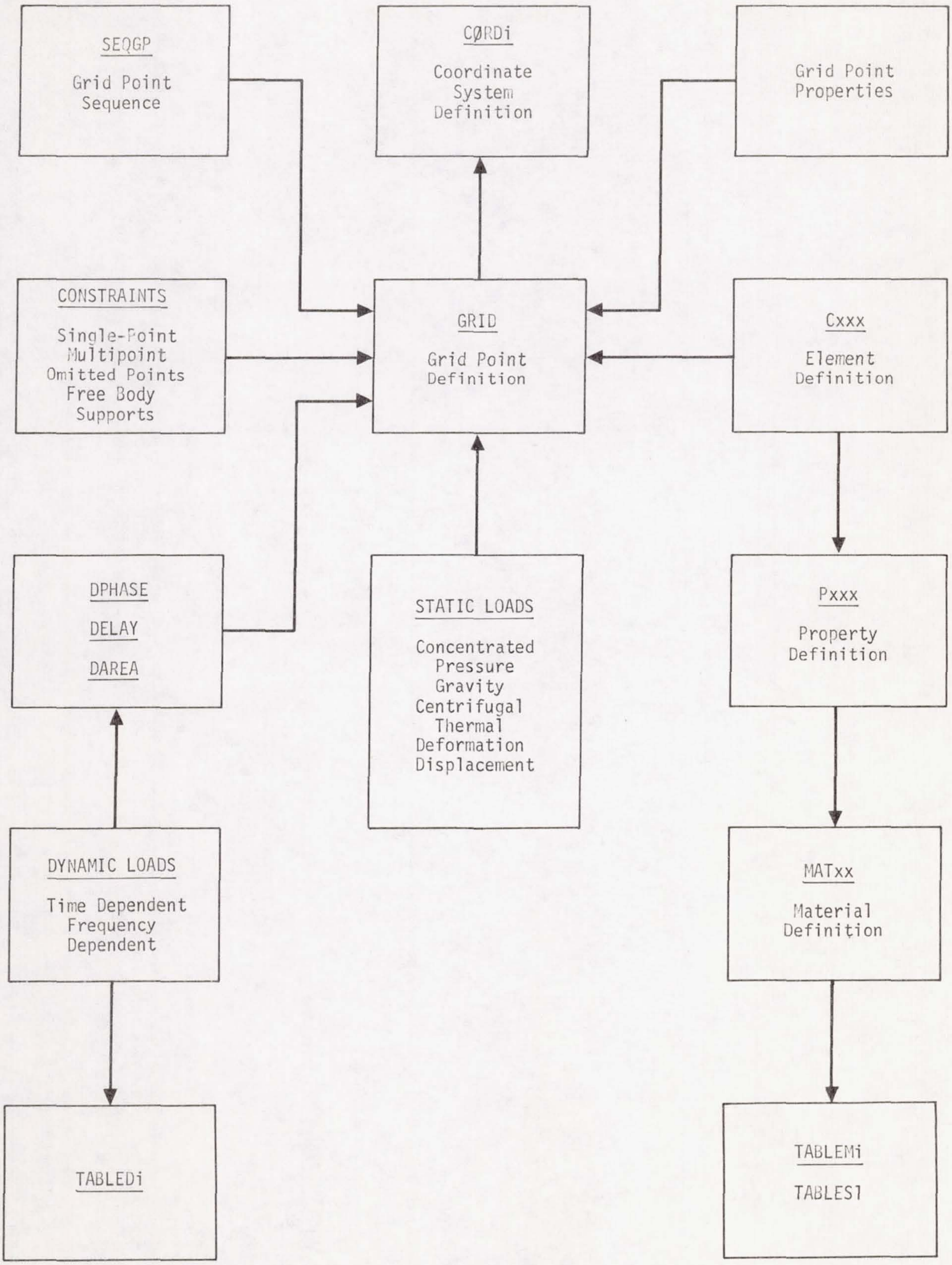


Figure 1. Structural model.

1.2 GRID POINTS

1.2.1 Grid Point Definition

Geometric grid points are defined on GRID bulk data cards by specifying their coordinates in either the basic or a local coordinate system. The implicitly defined basic coordinate system is rectangular, except when using axisymmetric elements. Local coordinate systems may be rectangular, cylindrical, or spherical. Each local system must be related directly or indirectly to the basic coordinate system. The CØRD1C, CØRD1R and CØRD1S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of three geometric grid points which have been previously defined. The CØRD2C, CØRD2R and CØRD2S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of the coordinates of three points in a previously defined coordinate system.

Six rectangular displacement components (3 translations and 3 rotations) are defined at each grid point. The local coordinate system used to define the directions of motion may be different from the local coordinate system used to locate the grid point. Both the location coordinate system and the displacement coordinate system are specified on the GRID card for each geometric grid point. The orientation of displacement components depends on the type of local coordinate system used to define the displacement components. If the defining local system is rectangular, the displacement system is parallel to the local system and is independent of the grid point location as indicated in Figure 1a. If the local system is cylindrical, the displacement components are in the radial, tangential and axial directions as indicated in Figure 1b. If the local system is spherical, the displacement components are in the radial, meridional, and azimuthal directions as indicated in Figure 1c. Each geometric grid point may have a unique displacement coordinate system associated with it. The collection of all displacement coordinate systems is known as the global coordinate system. All matrices are formed and all displacements are output in the global coordinate system. The symbols T1, T2 and T3 on the printed output indicate translations in the 1, 2, and 3-directions, respectively, for each grid point. The symbols R1, R2 and R3 indicate rotations about the three axes.

Provision is also made on the GRID card to apply single-point constraints to any of the displacement components. Any constraints specified on the GRID card will be automatically used for all solutions. Constraints specified on the GRID card are usually restricted to those degrees of

freedom that will not be elastically constrained and hence must be removed from the model in order to avoid singularities in the stiffness matrix.

The GRDSET card is provided to avoid the necessity of repeating the specification of location coordinate systems, displacement coordinate systems, and single-point constraints, when all, or many, of the GRID cards have the same entries for these items. When any of the 3 items are specified on the GRDSET card, the entries are used to replace blank fields on the GRID card for these items. This feature is useful in the case of such problems as space trusses where one wishes to remove all of the rotational degrees of freedom or in the case of plane structures where one wishes to remove all of the out-of-plane or all of the in-plane motions.

Scalar points are defined either on an SPØINT card or by reference on a connection card for a scalar element. SPØINT cards are used primarily to define scalar points appearing in constraint equations, but to which no structural elements are connected. A scalar point is implicitly defined if it is used as a connection point for any scalar element. Special scalar points, called "extra points", may be introduced for dynamic analyses. Extra points are used in connection with transfer functions and other forms of direct matrix input used in dynamic analyses and are defined on EPØINT cards.

GRIDB is a variation of the GRID card that is used to define a point on a fluid-structure interface (see Section 1.7).

1.2.2 Grid Point Sequencing

The best solution times are obtained if the grid points can be sequenced in such a manner as to create stiffness matrices having relatively narrow bands. In some cases the bandwidth can be substantially reduced by purposely sequencing a few of the grid points well outside the band. The resulting nonzero terms outside the band are treated individually by the triangular decomposition routines. Columns of a matrix containing nonzero terms outside the band are referred to as "active columns". The details of the partially banded decomposition routines are given in Section 2.2 of the Theoretical Manual. If the bandwidth is large enough to cause excessive use of secondary storage devices (spill) during the triangular decomposition of the stiffness matrix in static analysis, it may be more efficient to use the partitioning procedure described in Section 1.4.4.

Excluding grid points that are purposely sequenced outside the band, the bandwidths of stiffness matrices are proportional to the maximum difference between any two connected grid point

sequence numbers. The discussion and examples that follow will discuss bandwidths and active columns in terms of geometric grid points. Since each geometric grid point can have one to six degrees of freedom, the bandwidths of the resulting matrices are determined accordingly. The semiband is defined as the maximum number of columns included from the diagonal term in any row to the most remote term inside the band. If the diagonal terms are excluded, the semiband is proportional to the maximum difference between any two connected grid point numbers in the band. In the discussion of the examples, it is assumed that the grid points are connected with one-dimensional elements.

Examples of proper grid point sequencing for minimum bandwidth for one-dimensional systems are shown in Figure 2. For open loops, a consecutive numbering system should be used as shown in Figure 2a. Generally there is improvement in the accumulated roundoff error if the grid points are sequenced from the flexible end to the stiff end.

For closed loops the grid points should be sequenced as shown in Figure 2b. This model will have twice the semiband of the model shown in Figure 2a. If the sequencing is as shown in Figure 2c, the semiband will be half of that for the sequencing shown in Figure 2b. However, the connection between grid points 1 and 8 will create a number of active columns equal to the semiband, and the net result is that the semiband of the first case is equal to the sum of the semiband and number of active columns for the second case. Since it takes about twice as long to process active columns as terms inside the band, the sequence shown in Figure 2b is to be preferred.

Examples of grid point sequencing for surfaces are shown in Figure 3. For plane or curved surfaces where the pattern of grid points tends to be rectangular, the sequencing shown in Figure 3a will result in the shortest solution times. The semiband will be proportional to the number of grid points along the short direction of the pattern. If the pattern of grid points shown in Figure 3a is made into a closed surface by connecting grid points 1 and 17, 2 and 18, etc., a number of active columns equal to the semiband will be created. An alternate sequencing for a closed loop is shown in Figure 3b, where the semiband is proportional to twice the number of grid points in a row. For cylindrical or similar closed surfaces, the sequencing indicated in Figure 3b is more efficient if the number of grid points in the circumferential direction is more than twice the number in the axial direction. If the number of grid points in the circumferential direction is less than twice the number in the axial direction, the sequencing indicated in Figure 3a, with the consecutive numbering in the circumferential direction, is more efficient.

In general, sequences of grid points that generate active columns cannot be expected to shorten computing times substantially unless the semiband can be reduced by about two for each active

column introduced. This is not likely to be the case for most surfaces. An exception is the case of radial patterns, where the sequencing indicated in Figure 3c is the most efficient if there are more grid points on a circumferential line than on a radial line. In this case, the semiband is proportional to the number of grid points on a radial line, and the number of active columns is equal to the number of degrees of freedom at the center grid point. If there are more grid points on a radial line than a circumferential line, the consecutive numbering should extend in the circumferential direction, beginning with the outermost circumferential ring. In this case, the semiband is proportional to the number of grid points on a circumferential line and there are no active columns.

If the grid points form a full circular pattern, the closure will create a number of active columns proportional to the number of grid points on a radial line if the grid points are numbered as shown in Figure 3c. A more efficient scheme is to number the radial lines alternately, similar to the sequence shown for a rectangular array in Figure 3b. This sequence will result in shorter solution times if the number of grid points on a circumferential line is greater than twice the number on a radial line. The central point must be sequenced at the end in order to limit the active columns to the number of degrees of freedom at the central point. If the central point is sequenced first, the number of active columns will be proportional to the number of radial lines. If the number of grid points on a circumferential line is less than twice the number of grid points on a radial line, the consecutive numbering should extend in the circumferential direction. This sequencing procedure will result in a semiband proportional to the number of grid points on a circumferential line and no active columns. If the central point does not exist, the sequencing problem is similar to that discussed for rectangular arrays in connection with Figures 3a and 3b.

Sequencing problems for three-dimensional structures may be treated in two broad general classes. The first class consists of structural models that are compact, without appendages or connecting substructures. The second class consists of models that are composed of several substructures interconnected at a relatively small number of locations. Examples of the first type of model are solid structures, such as rectangular bars or cellular structures where an external shell is filled with bulkheads such as a submarine. For these types of structures the general procedure is to sequence the grid points in imaginary surfaces perpendicular to the largest axis of the structure. The grid point numbers are sequenced within each surface in the most effective

way, beginning at one end of the structure and proceeding to the other end. Assuming that only adjacent surfaces are connected, the semiband will be proportional to the largest number of grid points in a surface.

Examples of the second type of model are airframes and radio telescopes. For these types of structures, the general procedure is to sequence the individual substructures in the most effective way and allow the degrees of freedom associated with the connecting grid points to be treated as active columns. The computing time for terms outside the band is proportional to the total length of active columns, where the length of an active column is equal to the difference between the row number of the first nonzero term in the column and the row number of the extremity of the band. In sequencing the connecting grid points for two substructures, the number of active columns is minimized by sequencing the connecting grid points after both substructures. However, in many cases, the connecting grid points can be advantageously sequenced between the two parts or among the points of the second part. This procedure tends to increase the number of active columns, but reduces the length of each one. Sequencing the connecting grid points first or among the points of the first part tends to maximize both the number of active columns and the lengths of each one.

Although scalar points are defined only in vector space, the pattern of their connections is used in a manner similar to that of geometric grid points for sequencing scalar points among themselves or with geometric grid points. Since scalar points introduced for dynamic analysis (extra points) are defined in connection with direct input matrices, the sequencing of these points is determined by direct reference to the positions of the added terms in the dynamic matrices.

The external identification numbers used for grid points may be selected in any manner the user desires. However, in order to preserve the bandwidth of the stiffness matrix, and hence to substantially reduce computing times when using the displacement method, the internal sequencing of the grid points must not be arbitrary, In order to allow arbitrary external grid point numbers and still preserve sparsity in the triangular decomposition factors to the greatest extent possible, provision is made for the user to resequence the grid point numbers for internal operations. This feature also makes it possible to easily change the sequence if a poor initial choice is made. All output associated with grid points is identified with the external grid point numbers. The SEQGP card is used to resequence geometric grid points and scalar points. The SEQEP card is used to sequence the extra points in with the previously sequenced geometric grid points and scalar points.

1.2.3 Grid Point Properties

Some of the characteristics of the structural model are introduced as properties of grid points, rather than as properties of structural elements. Any of the various forms of direct matrix input are considered as describing the structural model in terms of properties of grid points.

Thermal fields are defined by specifying the temperatures at grid points. The TEMP card is used to specify the temperature at grid points for use in connection with thermal loading and temperature dependent material properties. The TEMPD card is used to specify a default temperature, in order to avoid a large number of duplicate entries on a TEMP card when the temperature is uniform over a large portion of the structure. The TEMPAX card is used for conical shell problems.

Mass properties may be input as properties of grid points by using the concentrated mass element (see Section 5.5 of the Theoretical Manual). The CØNM1 card is used to define a 6x6 matrix of mass coefficients at a geometric grid point in any selected coordinate system. The CØNM2 card is used to define a concentrated mass at a geometric grid point in terms of its mass, the three coordinates of its center of gravity, the three moments of inertia about its center of gravity, and its three products of inertia, referred to any selected coordinate system.

In dynamic analysis, mass, damping, and stiffness properties may be provided, in part or entirely, as properties of grid points through the use of direct input matrices. The DMIG card is used to define direct input matrices for use in dynamic analysis. These matrices may be associated with components of geometric grid points, scalar points, or extra points introduced for dynamic analysis. The TF card is used to define transfer functions that are internally converted to direct matrix input. The DMIAX card is an alternate form of direct matrix input that is used for hydroelastic problems (see Section 1.7).

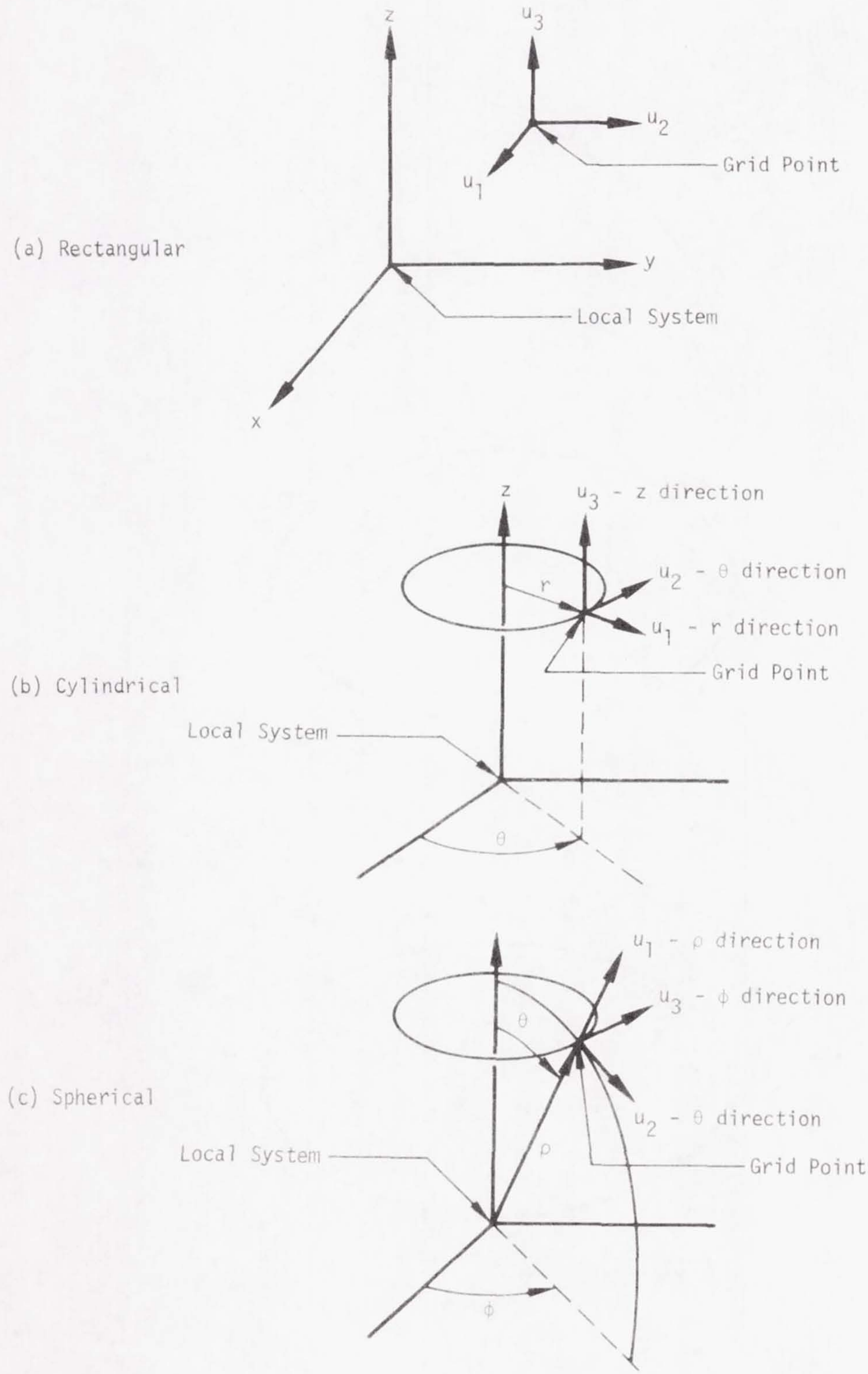


Figure 1. Displacement coordinate systems.

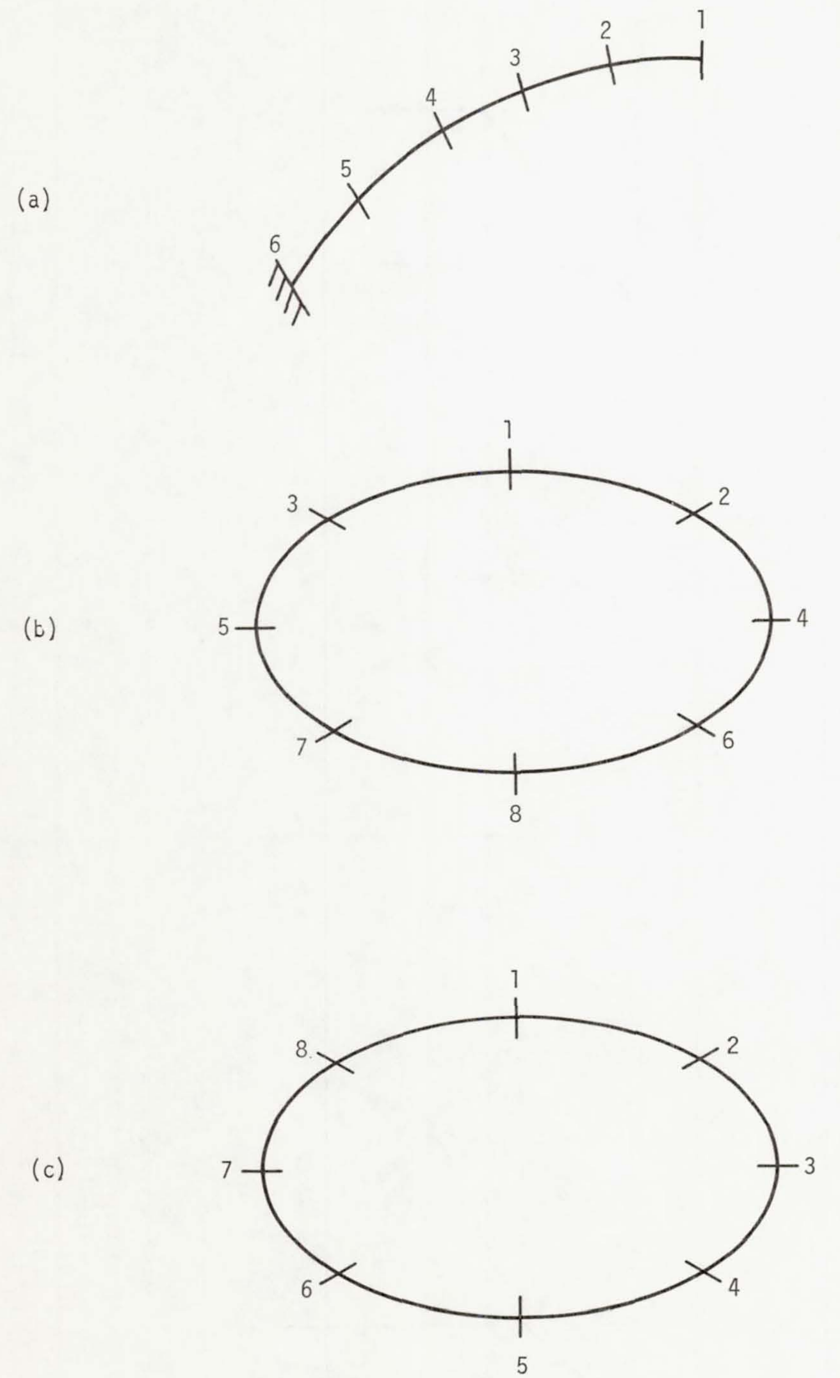


Figure 2. Grid point sequencing for one-dimensional systems.

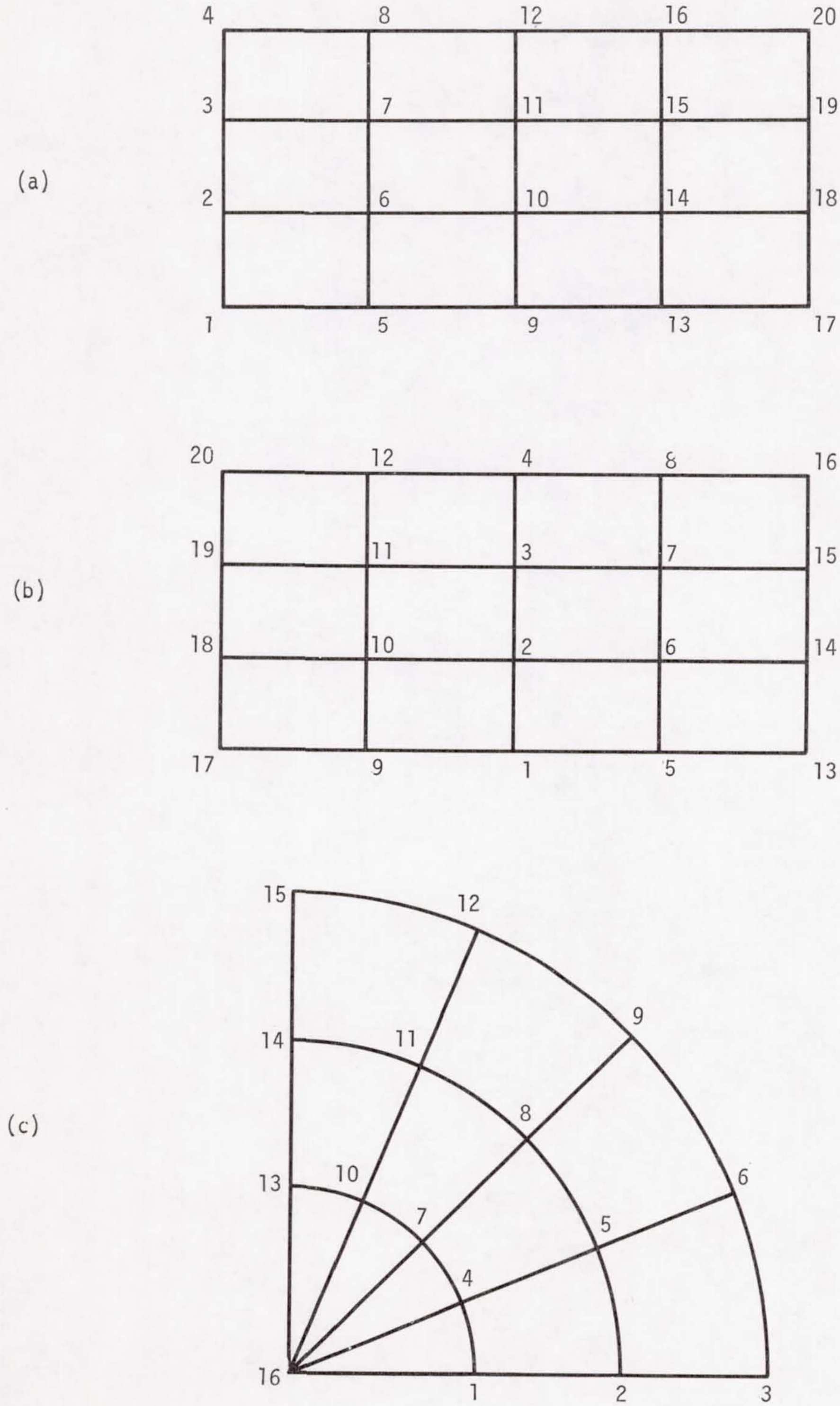


Figure 3. Grid point sequencing for surfaces.

1.3 STRUCTURAL ELEMENTS

1.3.1 Element Definition

Structural elements are defined on connection cards that identify the grid points to which the element is connected. The mnemonics for all such cards have a prefix of the letter "C", followed by an indication of the type of element, such as CBAR and CRØD. The order of the grid point identification defines the positive direction of the axis of a one-dimensional element and the positive surface of a plate element. The connection cards include additional orientation information when required. Except for the simplest elements, each connection card references a property definition card. If many elements have the same properties, this system of referencing eliminates a large number of duplicate entries.

The property definition cards define geometric properties such as thicknesses, cross-sectional areas, and moments of inertia. The mnemonics for all such cards have a prefix of the letter "P", followed by some, or all of the characters used on the associated connection card, such as PBAR and PRØD. Other included items are the nonstructural mass and the location of points where stresses will be calculated. Except for the simplest elements, each property definition card will reference a material property card.

In some cases, the same finite element can be defined by using different bulk data cards. These alternate cards have been provided for user convenience. In the case of a rod element, the normal definition is accomplished with a connection card (CRØD) which references a property card (PRØD). However, an alternate definition uses a CØNRØD card which combines connection and property information on a single card. This is more convenient if a large number of rod elements all have different properties.

In the case of plate elements, a different property card is provided for each type of element, such as membrane or sandwich plates. Thus, each property card contains only the information required for a single type of plate element, and in most cases, a single card has sufficient space for all of the property information. In order to maintain uniformity in the relationship between connection cards and property cards, a number of connection card types contain the same information, such as the connection cards for the various types of triangular elements. Also, the property cards for triangular and quadrilateral elements of the same type contain the same information.

The material property definition cards are used to define the properties for each of the materials used in the structural model. The MAT1 card is used to define the properties for isotropic materials. The MATS1 card specifies table references for isotropic material properties that are stress dependent. The TABLES1 card defines a tabular stress-strain function for use in Piecewise Linear Analysis. The MATT1 card specifies table references for isotropic material properties that are temperature dependent. The TABLEM1, TABLEM2, TABLEM3, and TABLEM4 cards define four different types of tabular functions for use in generating temperature-dependent material properties.

The MAT2 card is used to define the properties for anisotropic materials. The MATT2 card specifies table references for anisotropic material properties that are temperature dependent. This card may reference any of the TABLEM1, TABLEM2, TABLEM3, or TABLEM4 cards.

The MAT3 card is used to define the properties for orthotropic materials used in the modeling of axisymmetric shells. This card may only be referenced by CTRIARG, CTRAPRG, and PTØRDRG cards. The MATT3 card specifies table references for use in generating temperature-dependent properties for this type of material.

The GENEL card is used to define general elements whose properties are defined in terms of deflection influence coefficients or stiffness matrices, and which can be connected between any number of grid points. One of the important uses of the general element is the representation of part of a structure by means of experimentally measured data. No output data is prepared for the general element. Detail information on the general element is given in Section 5.7 of the Theoretical Manual.

Dummy elements are provided in order to allow the user to investigate new structural elements with a minimum expenditure of time and money. A dummy element is defined with a CDUMi (i = index of element type, $1 \leq i \leq 9$) card and its properties are defined with the PDUMi card. The ADUMi card is used to define the items on the connection and property cards. Detail instructions for coding dummy element routines are given in Section 6.8.5 of the Programmer's Manual.

1.3.2 Bar Element

The bar element is defined with a CBAR card and its properties (constant over the length) are defined with PBAR card. The bar element includes extension, torsion, bending in two perpendicular planes, and the associated shears. The shear center is assumed to coincide with the elastic axis. Any five of the six forces at either end of the element may be set equal to zero

by using the pin flags on the CBAR card. The integers 1 to 6 represent the axial force, shearing force in Plane 1, shearing force in Plane 2, axial torque, moment in Plane 2 and moment in Plane 1 respectively. The structural and nonstructural mass of the bar are lumped at the ends of the elements, unless coupled mass is requested with the PARAM card CØUPMASS (see Section 3.1.5). Theoretical aspects of the bar element are treated in Section 5.2 of the Theoretical Manual.

The element coordinate system is shown in Figure 1a. End a is offset from grid point a an amount measured by vector $\vec{w}_a$ and end b is offset from grid point b an amount measured by vector $\vec{w}_b$. The vectors $\vec{w}_a$ and $\vec{w}_b$ are measured in the global coordinates of the connected grid point. The x-axis of the element coordinate system is defined by a line connecting end a to end b of the bar element. The orientation of the bar element is described in terms of two reference planes. The reference planes are defined with the aid of vector $\vec{v}$. This vector may be defined directly with three components in the global system at end a of the bar or by a line drawn from end a to a third referenced grid point. The first reference plane (Plane 1) is defined by the x-axis and the vector $\vec{v}$. The second reference plane (Plane 2) is defined by the vector cross product ($\vec{x} \times \vec{v}$) and the x-axis. The subscripts 1 and 2 refer to forces and geometric properties associated with bending in planes 1 and 2 respectively. The reference planes are not necessarily principal planes. The coincidence of the reference planes and the principal planes is indicated by a zero product of inertia (I_{12}) on the PBAR card. If shearing deformations are included, the reference axes and the principal axes must coincide. When pin flags and offsets are used, the effect of the pin is to free the force at the end of the element x-axis of the beam, not at the grid point. The positive directions for element forces are shown in Figure 1b. The following element forces, either real or complex (depending on the rigid format), are output on request:

1. Bending moments at both ends in the two reference planes.
2. Shears in the two reference planes.
3. Average axial force.
4. Torque about the bar axis.

The following real element stresses are output on request:

1. Average axial stress.
2. Extensional stress due to bending at four points on the cross-section at both ends. (Optional, calculated only if user enters stress recovery points on PBAR card.)
3. Maximum and minimum extensional stresses at both ends.
4. Margins of safety in tension and compression for the whole element. (Optional, calculated only if user enters stress limits on MAT1 card.)

Tensile stresses are given a positive sign and compressive stresses a negative sign. Only the average axial stress and the extensional stresses due to bending are available as complex stresses. The stress recovery coefficients on the PBAR card are used to locate points on the cross-section for stress recovery. The subscript 1 is associated with the distance of a stress recovery point from plane 2. The subscript 2 is associated with the distance from plane 1.

The use of the BARØR card avoids unnecessary repetition of input when a large number of bar elements either have the same property identification number or have their reference axes oriented in the same manner. This card is used to define default values on the CBAR card for the property identification number and the orientation vector for the reference axes. The default values are used only when the corresponding fields on the CBAR card are blank.

1.3.3 Rod Element

The rod element is defined with a CRØD card and its properties with a PRØD card. The rod element includes extensional and torsional properties. The CØNRØD card is an alternate form that includes both the connection and property information on a single card. The tube element is a specialized form that is assumed to have a circular cross-section. The tube element is defined with a CTUBE card and its properties with a PTUBE card. The structural and nonstructural mass of the rod are lumped at the adjacent grid points unless coupled mass is requested with the PARAM card CØUPMASS (see Section 3.1.5). Theoretical aspects of the rod element are treated in Section 5.2 of the Theoretical Manual.

The x-axis, of the element coordinate system, is defined by a line connecting end a to end b as shown in Figure 2. The axial force and torque are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 2. The following real element stresses are output on request:

1. Axial stress
2. Torsional stress
3. Margin of safety for axial stress
4. Margin of safety for torsional stress.

Positive directions are the same as those indicated in Figure 2 for element forces. Only the axial stress and the torsional stress are available as complex stresses.

Another kind of rod element is the viscous damper, that has extensional and torsional viscous damping properties rather than stiffness properties. The viscous damper element is defined with a CVISC card and its properties with a PVISC card. This element is used in the direct formulation of dynamic matrices.

1.3.4 Shear Panels and Twist Panels

The shear panel is defined with a CSHEAR card and its properties with a PSHEAR card. A shear panel is a two-dimensional structural element that resists the action of tangential forces applied to its edges, but does not resist the action of normal forces. The structural and nonstructural mass of the shear panel are lumped at the connected grid points. Details of the shear panel element are discussed in Section 5.3 of the Theoretical Manual.

The element coordinate system for a shear panel is shown in Figure 3a. The integers 1, 2,3, and 4 refer to the order of the connected grid points on the CSHEAR card. The element forces are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 3b. These forces consist of the forces applied to the element at the corners in the direction of the sides, kick forces at the corners in a direction normal to the plane formed by the two adjacent edges, and "shear flows" (force per unit length) along the four edges. The shear stresses are calculated at the corners in skewed coordinates parallel to the exterior edges. The average of the four corner stresses and the maximum stress are output on request in either the real or complex form. A margin of safety is also output when the stresses are real.

The twist panel performs the same function for bending action that the shear panel performs for membrane action. The twist panel is defined with a CTWIST card and its properties with a PTWIST card. In calculating the stiffness matrix, a twist panel is assumed to be solid. For built-up panels, the thickness in the PTWIST card must be adjusted to give the correct moment of inertia of the cross-section. If mass calculations are being made, the density will also have to be adjusted on a MAT1 card. The element coordinate system and directions for positive forces are shown in Figure 4. Stress recovery is similar to that for shear panels.

1.3.5 Plate Elements

NASTRAN includes two different shapes of plate elements (triangular and quadrilateral) and two different stress systems (membrane and bending) which are uncoupled. There are in all a total of eleven different forms of plate elements that are defined by connection cards as follows:

1. CTRMEM - triangular element with finite inplane stiffness and zero bending stiffness.
2. CTRBSC - basic unit from which the bending properties of the other plate elements are formed.
3. CTRPLT - triangular element with zero inplane stiffness and finite bending stiffness.
4. CTRIA1 - triangular element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

5. CTRIA2 - triangular element with both inplane and bending stiffness that assumes a solid homogeneous cross section.

6. CQDMEM - quadrilateral element consisting of four overlapping CTRMEM elements.

7. CQDMEM1 - an isoparametric quadrilateral membrane element.

8. CQDMEM2 - a quadrilateral membrane element consisting of four nonoverlapping CTRMEM elements.

9. CQDPLT - quadrilateral element with zero inplane stiffness and finite bending stiffness.

10. CQUAD1 - quadrilateral element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

11. CQUAD2 - quadrilateral element with both inplane and bending stiffness that assumes a solid homogeneous cross section.

Theoretical aspects of the plate elements are treated in Section 5.8 of the Theoretical Manual.

The properties for the above elements are defined on the PTRMEM, PTRBSC, PTRPLT, PTRIA1, PTRIA2, PQDMEM, PQDMEM1, PQDMEM2, PQDPLT, PQUAD1, and PQUAD2 cards respectively. Anisotropic material may be specified for all plate elements. Transverse shear flexibility may be included for all bending elements on an optional basis, except for homogeneous plates (CTRIA2 and CQUAD2), where this effect is automatically included. Structural mass is calculated only for elements that specify a membrane thickness and is based only on the membrane thickness. Nonstructural mass can be specified for all plate elements, except the basic bending triangle. Only lumped mass procedures are used for membrane elements. Coupled mass procedures may be requested for elements that include bending stiffness with the PARAM card CØUPMASS (see Section 3.1.5). Differential stiffness matrices are generated for the following plate elements: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2. The following plate elements may have nonlinear material characteristics in Piecewise Linear Analysis: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2.

The element coordinate systems for triangular and quadrilateral plate elements are shown in Figure 5. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the connection cards defining the elements. The angle θ is the orientation angle for anisotropic materials.

Average values of element forces are calculated for all plate elements having a finite bending stiffness. The positive directions for plate element forces in the element coordinate system are shown in Figure 6a. The following element forces per unit of length, either real or complex, are output on request:

1. Bending moments on the x and y faces.

2. Twisting moment.

3. Shear forces on the x and y faces.

The CQDMEM2 is the only membrane element for which element forces are calculated. The positive directions for these forces are shown in Figure 3b, and the force output has the same interpretation as the force output for the shear panel discussed previously.

Average values of the membrane stresses are calculated for the triangular and quadrilateral membrane elements, with the exception of the CQDMEM1 element. For the CQDMEM1 element, in which the stress field varies, the stresses are evaluated at the intersection of diagonals (in a mean plane if the element is warped). The positive directions for the membrane stresses are shown in Figure 6b. The stresses for the CQDMEM2 element are calculated in the material coordinate system. The material coordinate system is defined by the material orientation angle on the CQDMEM2 card. The stresses for all other membrane elements are calculated in the element coordinate system.

The following real membrane stresses are output on request:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

Only the normal stresses and shearing stress are available in the complex form.

If the plate element has bending stiffness the average stresses are calculated on the two faces of the plate for homogeneous plates and at two specified points on the cross-section for other plate elements. The distances to the specified points are given on the property cards. The positive directions for these fiber distances are defined according to the right-hand sequence of the grid points specified on the connection card. These distances must be nonzero in order to obtain nonzero stress output. The same stresses are calculated for each of the faces as are calculated for membrane elements.

The quadrilateral plate elements are intended for use when the surfaces are reasonably flat and the geometry is nearly rectangular. For these conditions the quadrilateral elements eliminate the modeling bias associated with the use of triangular elements, and quadrilaterals give more accurate results for the same mesh size. If the surfaces are highly warped, curved or swept, triangular elements should be used. Under extreme conditions quadrilateral elements will give results that are considerably less accurate than triangular elements for the same mesh size. Quadrilateral elements should be kept as nearly square as practicable, as the accuracy tends to deteriorate as the aspect ratio of the quadrilateral increases. Triangular elements should be kept as nearly equilateral as practicable, as the accuracy tends to deteriorate as the triangles become obtuse and as the ratio of the longest to the shortest side increases.

1.3.6 Conical Shell Element

The properties of the conical shell element are assumed to be symmetrical with respect to the axis of the shell. However, the loads and deflections need not be axisymmetric, as they are expanded in Fourier series with respect to the azimuthal coordinate. Due to symmetry, the resulting load and deformation systems for different harmonic orders are independent, a fact that results in a large time saving when the use of the conical shell element is compared with an

equivalent model constructed from plate elements. Theoretical aspects of the conical shell element are treated in Section 5.9 of the Theoretical Manual.

At present the conical shell element cannot be combined with other types of elements. The existence of a conical shell problem is defined by the AXIC card. This card also indicates the number of harmonics desired in the problem formulation. Only a limited number of bulk data cards are allowed when using conical shell elements. The list of allowable cards is given on the AXIC card description in Section 2.4.2.

The geometry of a problem using the conical shell element is described with RINGAX cards instead of GRID cards. The RINGAX cards describe concentric circles about the basic z-axis, with their locations given by radii and z-coordinates as shown in Figure 7. The degrees of freedom defined by each RINGAX card are the fourier coefficients of the motion with respect to angular position around the circle. For example the radial motion, u_r, at any angle, ϕ, is described by the equation:

$$u_r(\phi) = \sum_{n=0}^{N} u_r^n \cos n\phi + \sum_{n=0}^{N} u_r^{n*} \sin n\phi \;, \qquad (1)$$

where u_r^n and u_r^{n*} are the fourier coefficients of radial motion for the n-harmonic. For calculation purposes the series is limited to N harmonics as defined by the AXIC card. The first sum in the above equation describes symmetric motion with respect to the $\phi = 0$ plane. The second sum with the "starred" (*) superscripts describes the antisymmetric motion. Thus each RINGAX data card will produce six times N degrees of freedom for each series.

The selection of symmetric or antisymmetric solutions is controlled by the AXISYM card in the Case Control Deck. For general loading conditions, a combination of the symmetric and antisymmetric solutions must be made, using the SYMCØM card in the Case Control Deck (Section 2.3 of the User's Manual).

Since the user is rarely interested in applying his loads in terms of fourier harmonics and interpreting his data by manually performing the above summations, NASTRAN is provided with special data cards which automatically perform these operations. The PØINTAX card is used like a GRID card to define physical points on the structure for loading and output. Sections of the circle may be defined by a SECTAX card which defines a sector with two angles and a referenced RINGAX card. The PØINTAX and SECTAX cards define six degrees of freedom each. The basic coordi-

nate system for these points is a cylindrical system (r, ϕ, z) and their applied loads must be described in this coordinate system. Since the displacements of these points are dependent on the harmonic motions, they may not be constrained in any manner.

The conical shell element is connected to two RINGAX points with a CCØNEAX card. The properties of the conical shell element are described on the PCØNEAX card. The RINGAX points must be placed on the neutral surface of the element and the points for stress calculation must be given on the PCØNEAX card relative to the neutral surface. Up to fourteen angular positions around the element may be specified for stress and force output. These values will be calculated midway between the two connected rings.

The structure defined with RINGAX and CCØNEAX cards must be constrained in a special manner. All harmonics may be constrained for a particular degree of freedom on a ring by using permanent single-point constraints on the RINGAX cards. Specified harmonics of each degree of freedom on a ring may be constrained with a SPCAX card. This card is the same as the SPC card except that a harmonic must be specified. The MPCAX, ØMITAX, and SUPAX data cards correspond to the MPC, ØMIT, and SUPØRT data except that harmonics must be specified. SPCADD and MPCADD cards may be used to combine constraint sets in the usual manner.

The conical shell structure may be loaded in various ways. Concentrated forces may be described by FØRCE and MØMENT cards applied to PØINTAX points. Pressure loads may be input in the PRESAX data card which defines an area bounded by two rings and two angles. Temperature fields are described by a paired list of angles and temperatures around a ring as required by the TEMPAX card. Direct loads on the harmonics of a RINGAX point are given by the FØRCEAX and MØMAX card. Since the basic coordinate system is cylindrical the loads are given in the r, ϕ, and z directions. The value of a harmonic load F_n is the total load on the whole ring of radius r. If a sinusoidal load per unit length of maximum value a_n is given, the value on the FØRCEAX card must be:

$$F_n = 2\pi\, r\, a_n \qquad n = 0\ , \tag{2}$$

$$F_n = \pi\, r\, a_n \qquad n > 0 \tag{3}$$

Displacements of rings and forces in conical shell elements can be requested in two ways:

1. The harmonic coefficients of displacements on a ring or forces in a conical element.
2. The displacements at specified points or the average value over a specified sector of a ring. The forces in the element at specified azimuths or average values over specified sectors of a conical element.

Harmonic output is requested by ring number for displacements and conical shell element number for element forces. The number of harmonics that will be output for any request is a constant for any single execution. This number is controlled by the HARMØNICS card in the Case Control Deck (see Section 2.3).

The following element forces per unit of width are output either as harmonic coefficients or at specified locations on request:

1. Bending moments on the u and v faces
2. Twisting moments
3. Shearing forces on the u and v faces

The following element stresses are calculated at two specified points on the cross-section of the element and output either as harmonic coefficients or at specified locations on request:

1. Normal stresses in u and v directions
2. Shearing stress on the u face in the v direction
3. Angle between the u-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

1.3.7 Axisymmetric Shell Elements

Two types of elements are provided that have an axisymmetric geometric configuration and that are restricted to axisymmetric applied loading. The first type is the ring element, which may have a triangular or trapezoidal cross-section and in the limiting case becomes a solid core element (see Section 5.11 of the Theoretical Manual). These elements are used for the modeling of axisymmetric thick walled structures of arbitrary profile. The second type is the toroidal ring element, which in the limiting case becomes a cap element (see Section 5.10 of the Theoretical Manual). The two types of axisymmetric ring elements cannot be used together nor can either of the elements be used with any other elements. Otherwise, these elements are used in a conventional manner, and except for their own connection and property cards, do not have special bulk data cards.

The coordinate system for the triangular ring element is shown on Figure 8. The cylindrical system is implied by the use of the triangular ring element. Hence, no explicit definition of the basic cylindrical coordinate system is required. Cylindrical anisotropy is optional for the

material properties in the ring element. Orientation of the orthotropic axes in the (r,z) plane is specified by the angle θ. Deformation behavior of the element is described in terms of translations in the r and z directions at each of the 3 connected grid points. All other degrees of freedom should be constrained.

The triangular ring element is defined with a CTRIARG card. No property card is used for this element. The material property reference is given on the connection card. The integers 1, 2 and 3 on Figure 8 refer to the order of the connected grid points on the CTRIARG card. This order must be counter-clockwise around the element. The grid points must lie in the r-z plane of the basic cylindrical coordinate system, and they must lie to the right of the axis of symmetry.

The radial and axial forces at each connected grid point are output on request. The positive directions for these forces are shown in Figure 8. These are apparent element forces and they include any equivalent thermal loads. The stresses at the centroid of an element are output on request. The available quantities are the normal stresses in the radial, circumferential and axial directions, and the shear stress on the radial face in the axial direction. Positive stresses are in the positive direction on the positive face.

The coordinate system for the trapezoidal ring element is shown in Figure 9. This element is similar to the triangular ring element. This element has the additional restriction that the element numbering must begin at the lower left hand corner of the element. Also, the parallel faces of the trapezoid must be perpendicular to the axis of symmetry. This element can be used in the limiting case where the r coordinates associated with grid points 1 and 4 are zero. In this special case the element is referred to as a core element.

The trapezoidal ring element is defined with a CTRAPRG card in a manner similar to that for a triangular element. The forces at the four connected grid points are provided on request in a manner similar to that for a triangular element. In addition to providing the stresses at the centroid of the trapezoid, similar stresses are provided at the four connected grid points.

The coordinate system for the toroidal ring is shown in Figure 10. This cylindrical coordinate system is implied by the use of the toroidal element, and hence, no explicit definition is required. The toroidal element may use orthotropic materials. The axes of orthotropy are assumed to coincide with the element coordinate axes.

Deformation behavior of the toroidal element is described by five degrees of freedom for each

of the two grid rings which it connects. The degrees of freedom in the implicit coordinate system are:

1. $\bar{u}$ - radial displacement
2. Not defined for toroidal element (must be constrained)
3. $\bar{w}$ - axial displacement
4. $w' = \frac{\partial w}{\partial \xi}$ slope in ξ-direction
5. $u' = \frac{\partial u}{\partial \xi}$ strain in ξ-direction
6. $w'' = \frac{\partial^2 w}{\partial \xi^2}$ curvature in $z\xi$-plane

The displacements $\bar{u}$ and $\bar{w}$ are in the basic coordinate system, and hence can be expressed in other local coordinate systems if desired. However, the quantities u', w' and w" are always in the element coordinate system.

The toroidal ring element is defined with a CTØRDRG card and its properties with a PTØRDRG card. The integers 1 and 2 on Figure 10 refer to the order of the connected grid points on the CTØRDRG card. The grid points must lie in the r-$\bar{z}$ plane of the basic coordinate system and they must lie to the right of the axis of symmetry. The angles α_1 and α_2 in Figure 10 are the angles of curvature and are defined as the angle measured in degrees from the axis of symmetry to a line which is perpendicular to the tangent to the surface at grid points 1 and 2 respectively. For conic rings $\alpha_1 = \alpha_2$ and for cylindrical rings $\alpha_1 = \alpha_2 = 90$ degrees. Toroidal elements may be connected to form closed figures in the r-$\bar{z}$ plane, but slope discontinuities are not permitted at connection points.

The following forces, evaluated at each end of the toroidal element, are output on request:

1. Radial force
2. Axial force
3. Meridional moment
4. A generalized force which corresponds to the w' degree of freedom.
5. A generalized force which corresponds to the w" degree of freedom.

The first three forces are referenced to the global coordinate system and the two generalized forces are referenced to the element coordinate system. For a definition of the generalized forces see Section 5.10 of the Theoretical Manual.

The following stresses, evaluated at both ends and the midspan of each element, are output on request:

1. Tangential membrane stress (Force per unit length)
2. Circumferential membrane stress (Force per unit length)
3. Tangential bending stress (Moment per unit length)
4. Circumferential bending stress (Moment per unit length)
5. Shearing stress (Force per unit length)

The positive directions for these stresses are indicated in Figure 11.

1.3.8 Scalar Elements

Scalar elements are connected between pairs of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Scalar elements are available as springs, masses and viscous dampers. Scalar spring elements are useful for representing elastic properties that cannot be conveniently modeled with the usual metric structural elements. Scalar masses are useful for the selective representation of inertia properties, such as occurs when a concentrated mass is effectively isolated for motion in one direction only. The scalar damper is used to provide viscous damping between two selected degrees of freedom or between one degree of freedom and ground. It is possible, using only scalar elements and constraints, to construct a model for the linear behavior of any structure. However it is expected that these elements will be used only when the usual metric elements are not satisfactory. Scalar elements are useful for modeling part of a structure with its vibration modes or when trying to consider electrical or heat transfer properties as part of an overall structural analysis. The reader is referred to Sections 5.5 and 5.6 of the Theoretical Manual for further discussions on the use of scalar elements.

The most general definition of a scalar spring is given with a CELAS1 card. The associated properties are given on the PELAS card. The properties include the magnitude of the elastic spring, a damping coefficient, and a stress coefficient to be used in stress recovery. The CELAS2 defines a scalar spring without reference to a property card. The CELAS3 card defines a scalar spring that is connected only to scalar points and the properties are given on a PELAS card. The CELAS4 card defines a scalar spring that is connected only to scalar points and without reference

to a property card. No damping coefficient or stress coefficient is available with the CELAS4 card.

Scalar elements may be connected to ground without the use of constraint cards. Grounded connections are indicated on the connection card by leaving the appropriate scalar identification number blank. Since the values for scalar elements are not functions of material properties, no references to such cards are needed.

The CMASS1, CMASS2, CMASS3 and CMASS4 cards define scalar masses in a manner similar to the scalar spring definitions. The associated PMASS card contains only the magnitude of the scalar mass.

The CDAMP1, CDAMP2, CDAMP3 and CDAMP4 cards define scalar dampers in a manner similar to the scalar spring definitions. The associated PDAMP card contains only a value for the scalar damper.

1.3.9 Solid Polyhedron Elements

Three types of solid polyhedron elements are provided for the general solid structures (see Section 1.3.7 for axisymmetric structures with axisymmetric loads). These elements (see Figure 12) are a *tetrahedron*, a *wedge* and a *hexahedron*. The theory is given in Section 5.12 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to displacement degrees of freedom at the grid points.

The elements are defined by CTETRA, CWEDGE, CHEXA1, and CHEXA2 connection cards. The user should specify grid locations such that the quadrilateral faces are nearly planar. No special element coordinate system is required. The only properties required are material properties, thus no PID card is referenced; direct reference is made to a MID card. For thermal stress problems, the temperature is assumed to be the average of the connected grid points. Differential stiffness, buckling, and piecewise linear analyses have not been implemented.

The output stresses are given in the basic coordinate system. In addition to the six normal and shear stresses, output also includes the pressure

$$p_o = -\frac{1}{3}(\sigma_x + \sigma_y + \sigma_z)$$

and the octahedral stress

$$\sigma_o = \frac{1}{3}\left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6\tau_{yz}^2 + 6\tau_{zx}^2 + 6\tau_{xy}^2\right]^{1/2}$$

The stresses in the tetrahedra are constant. The stresses in the wedge and the hexahedron are obtained as the weighted average of the stresses in the subtetrahedra. The weighting factor for each tetrahedra is proportional to its volume.

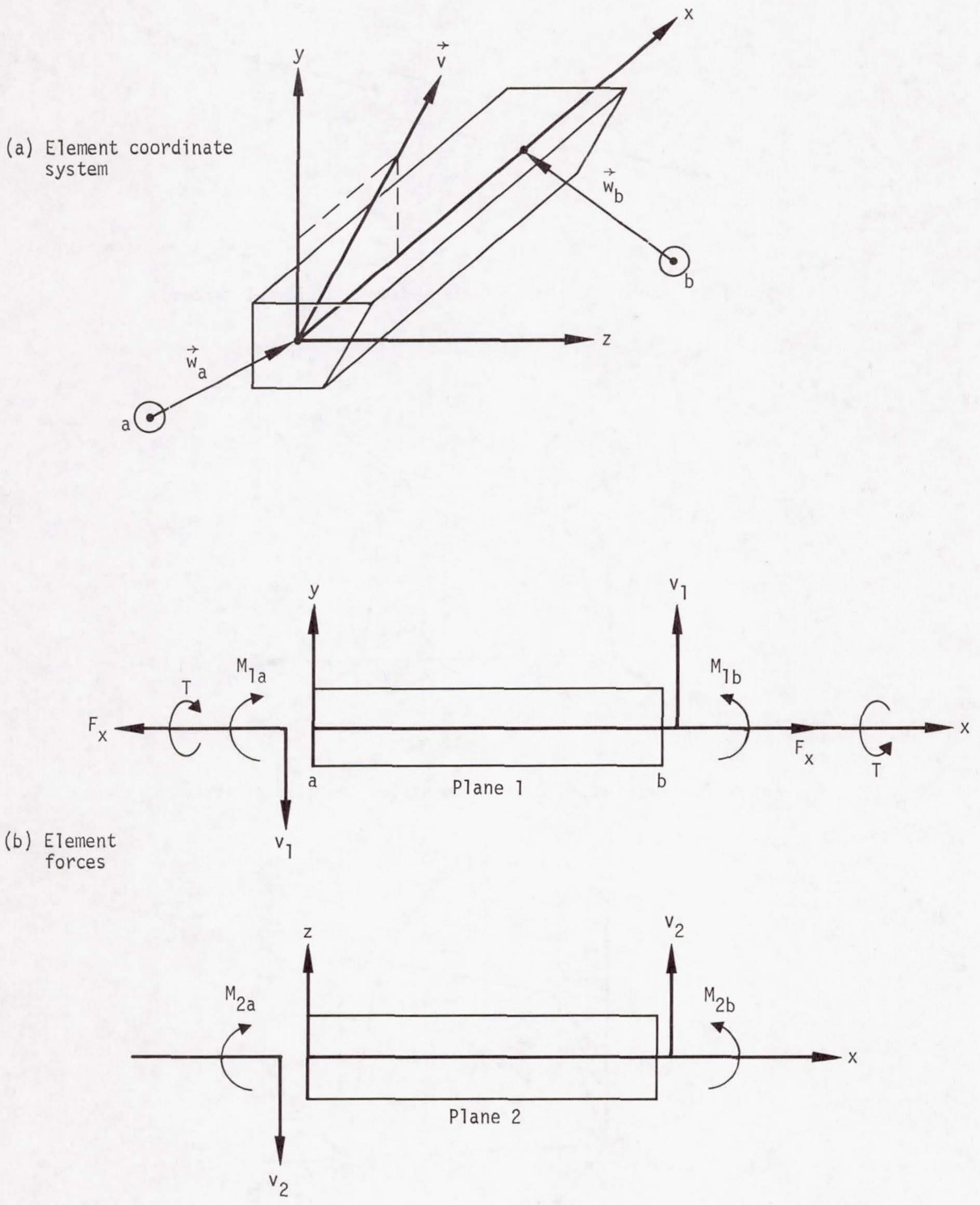


Figure 1. Bar element coordinate system and element forces.

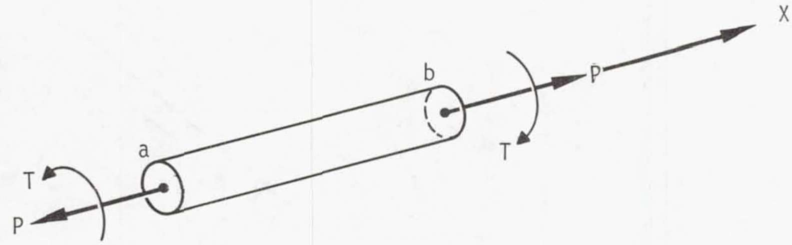


Figure 2. Rod element coordinate system and element forces

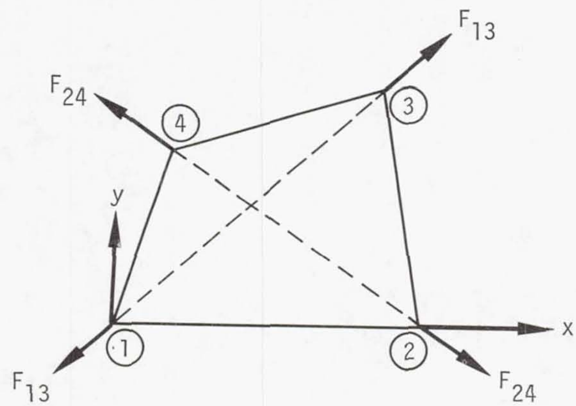


Figure 3. Shear panel coordinate system and element forces

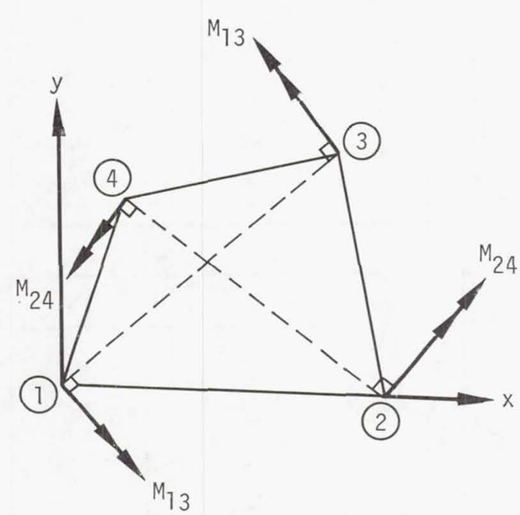
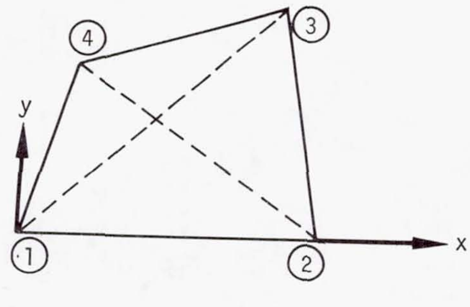
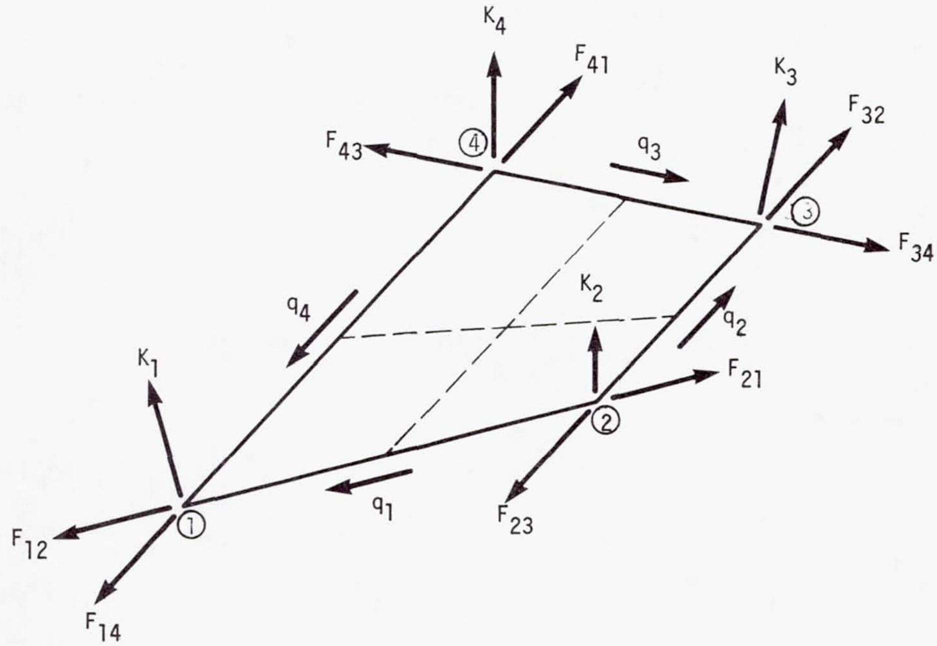


Figure 4. Twist panel coordinate system and element forces.



(a) Coordinate System.



(b) Corner forces and shear flows.

Figure 3. Coordinate system and element forces for shear panel and CQDMEM2 elements.

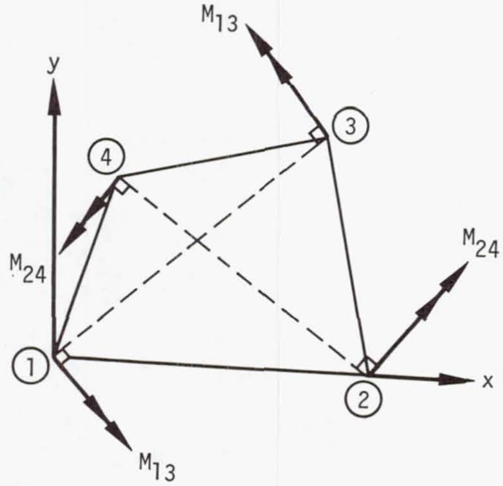


Figure 4. Twist panel coordinate system and element forces.

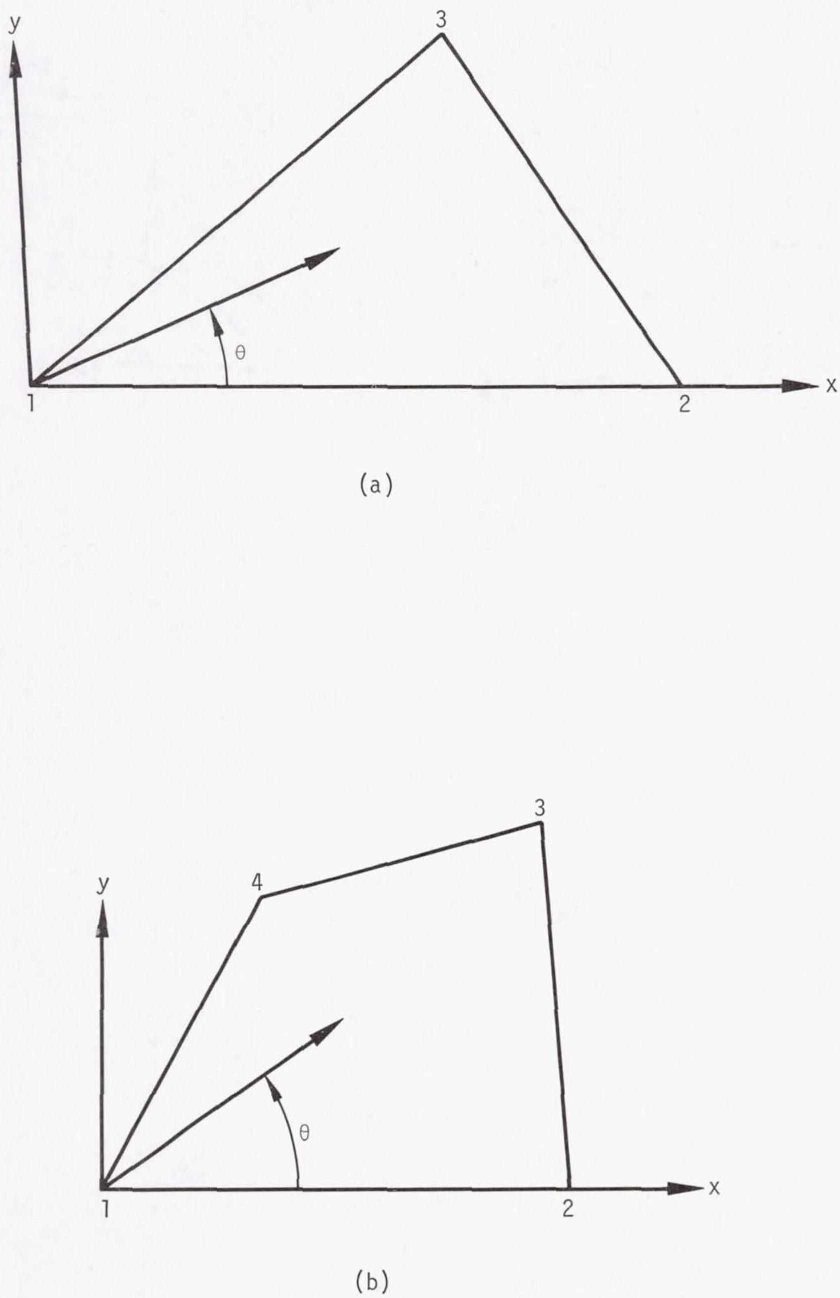


Figure 5. Plate element coordinate systems.

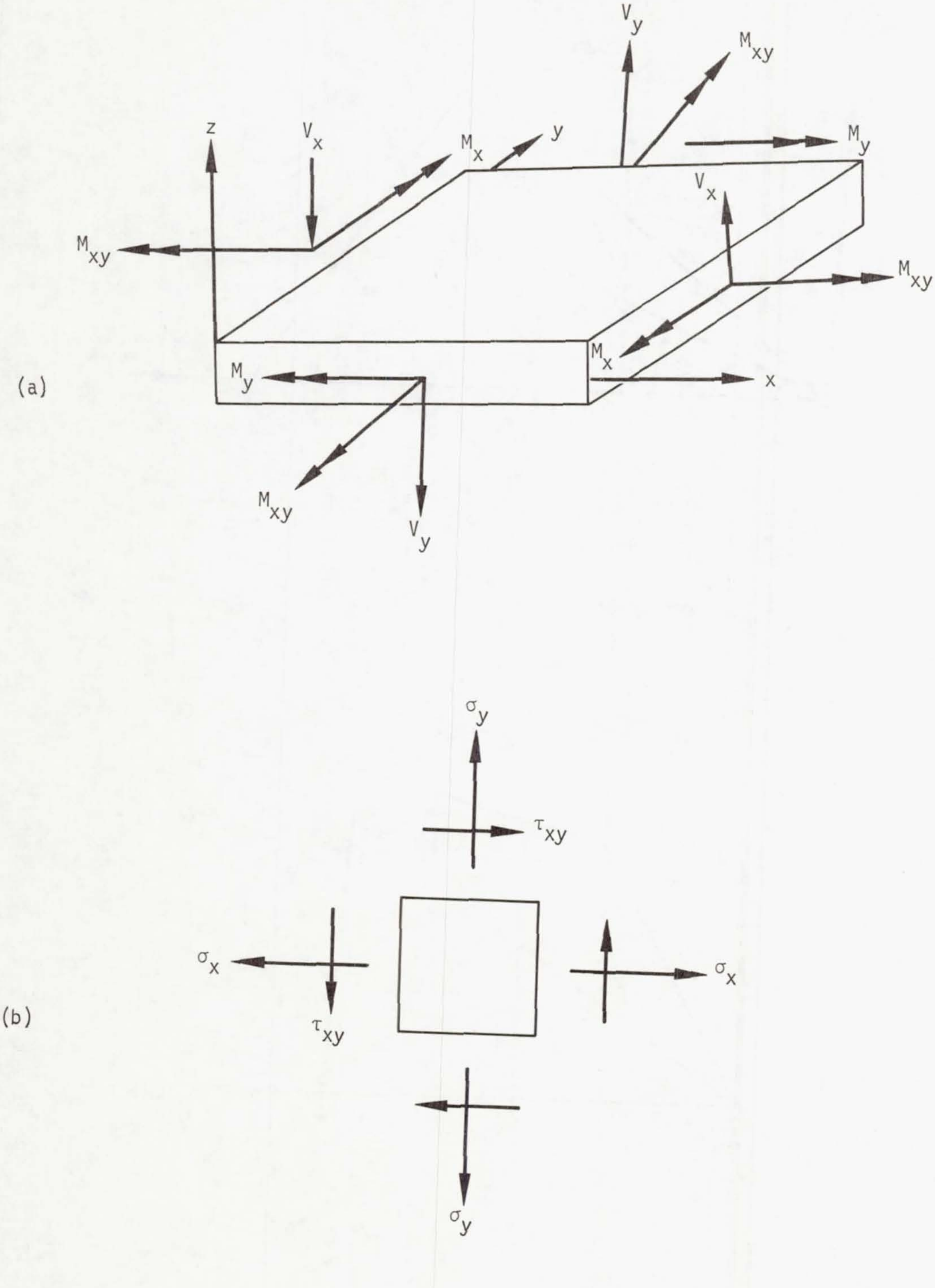


Figure 6. Forces and stresses in plate elements.

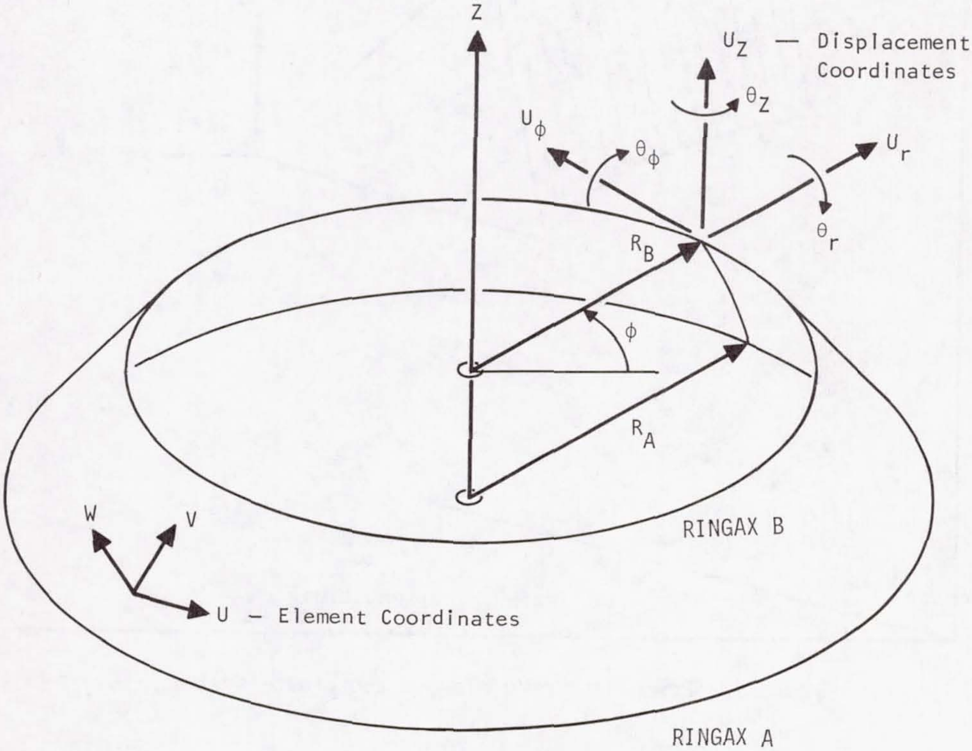


Figure 7. Geometry for conical shell element.

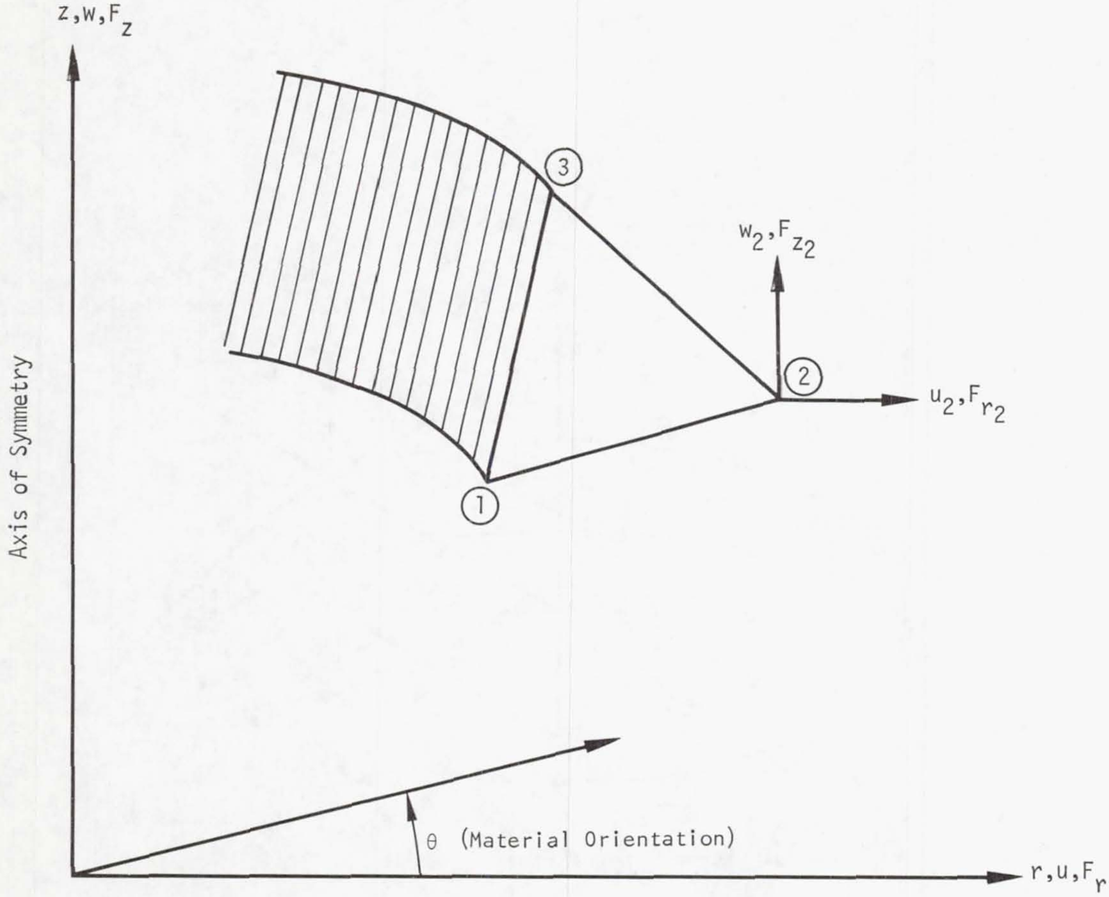


Figure 8. Triangular ring element coordinate system.

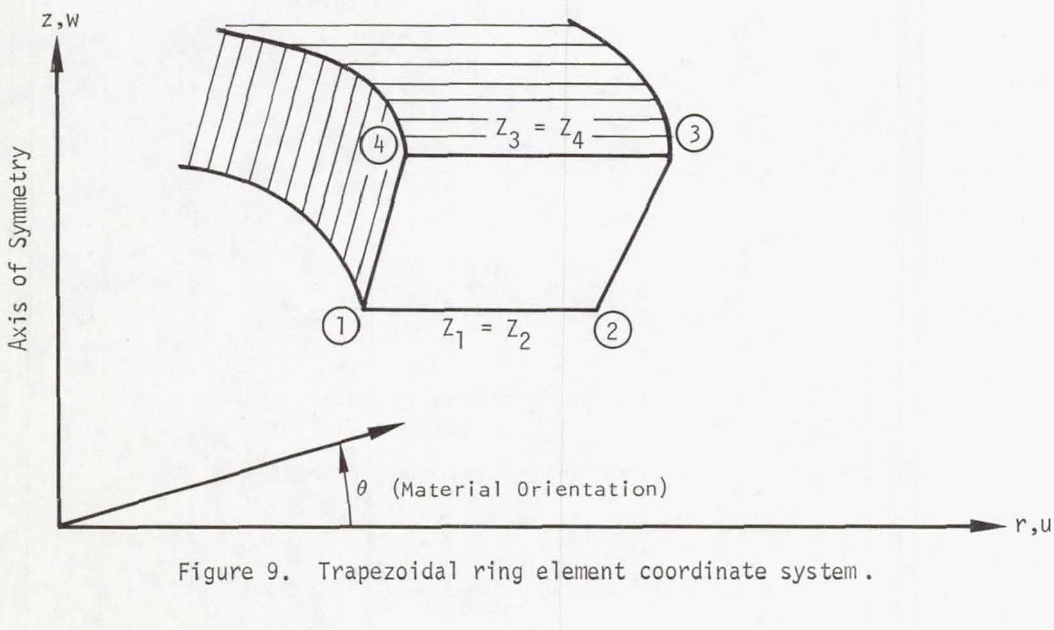


Figure 9. Trapezoidal ring element coordinate system.

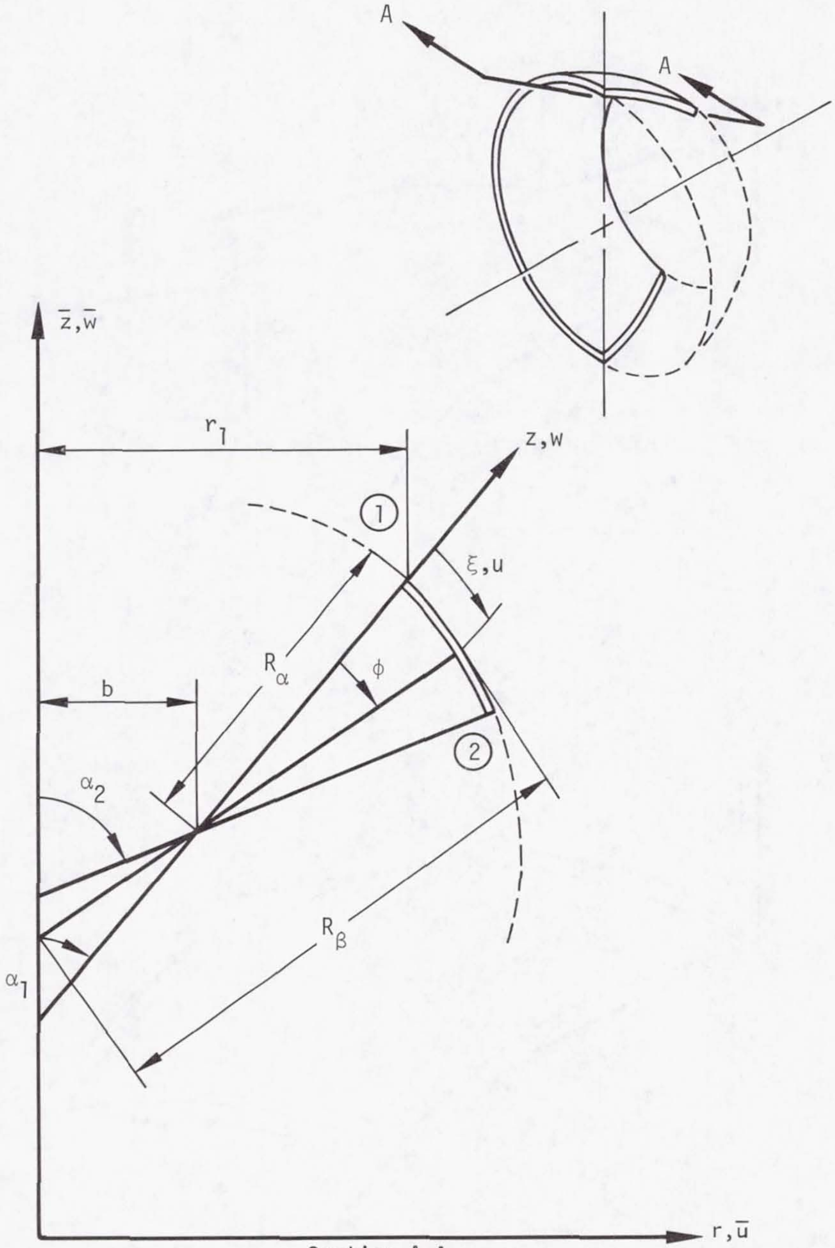


Figure 10. Toroidal ring element coordinate system.

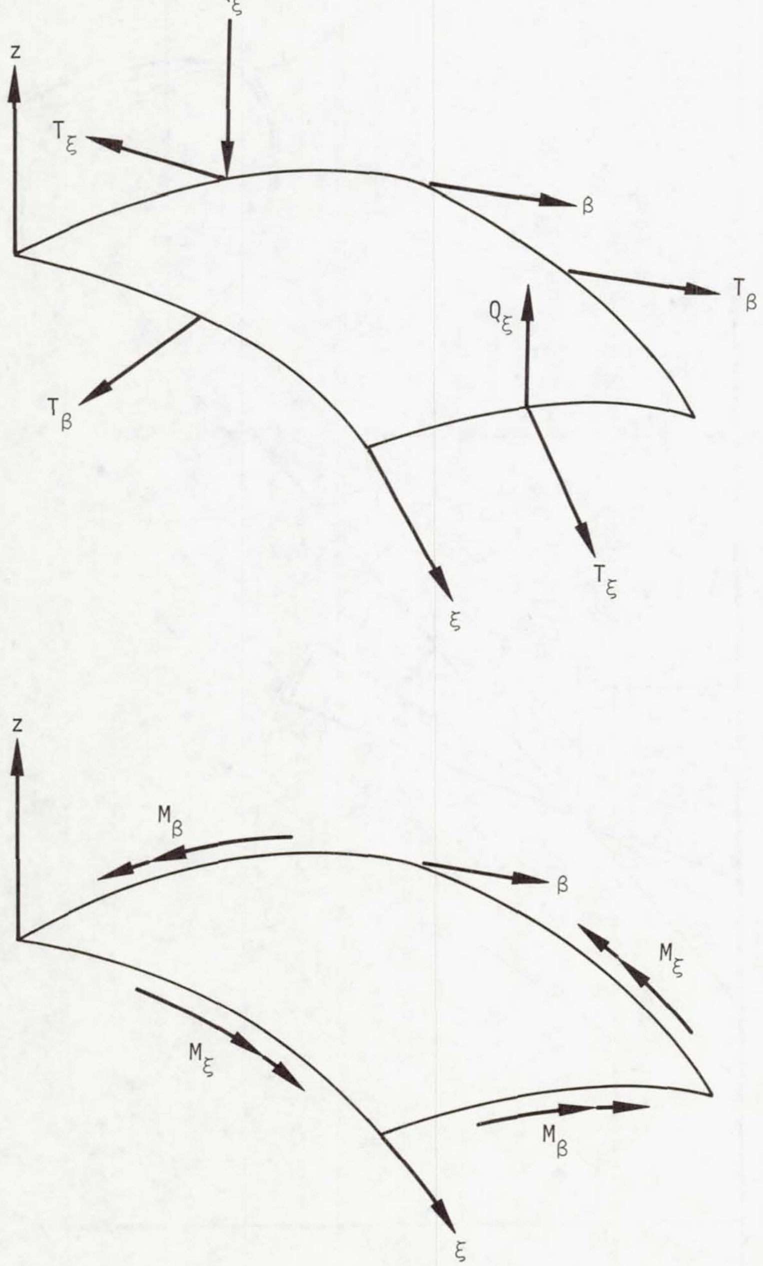
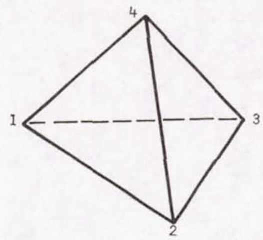
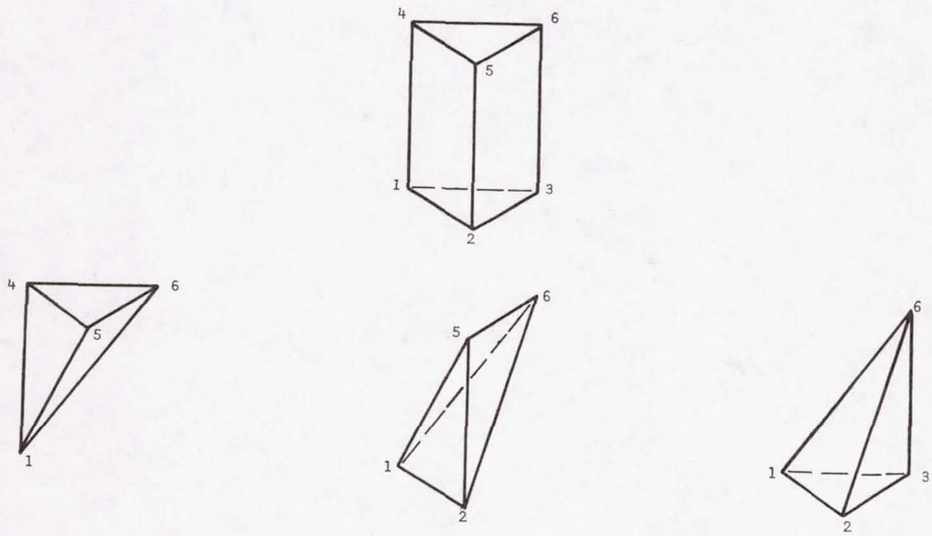


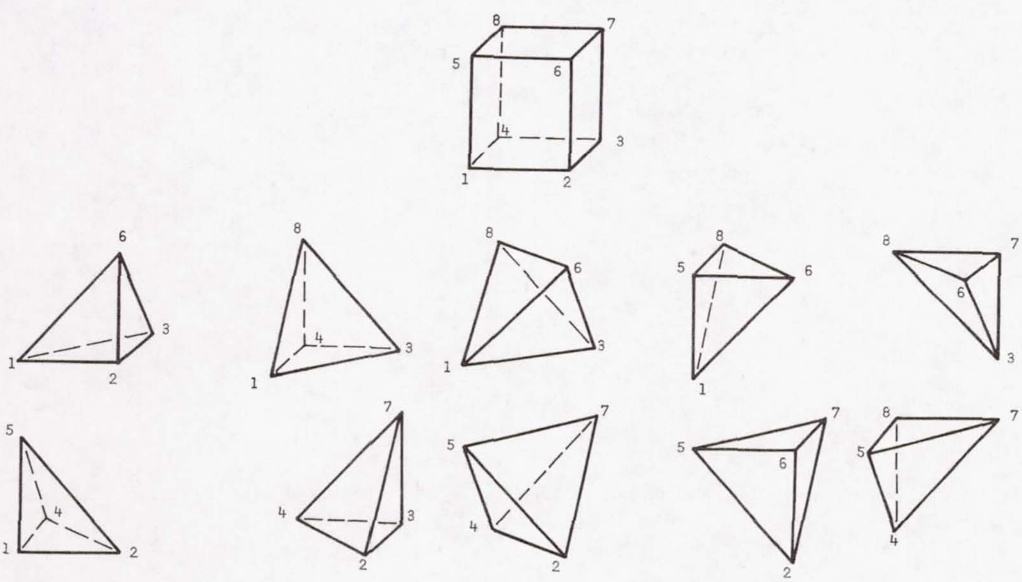
Figure 11. Stresses for toroidal element.



(a) Tetrahedron.

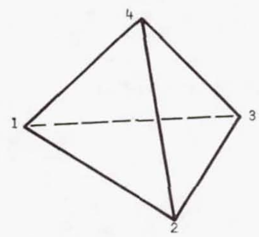


(b) Wedge and One of its Six Decompositions.

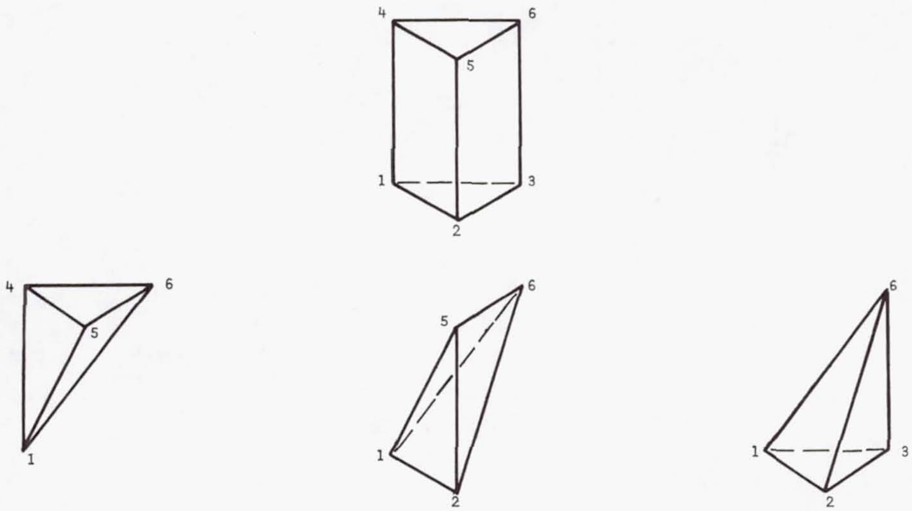


(c) Hexahedron and its Two Decompositions.

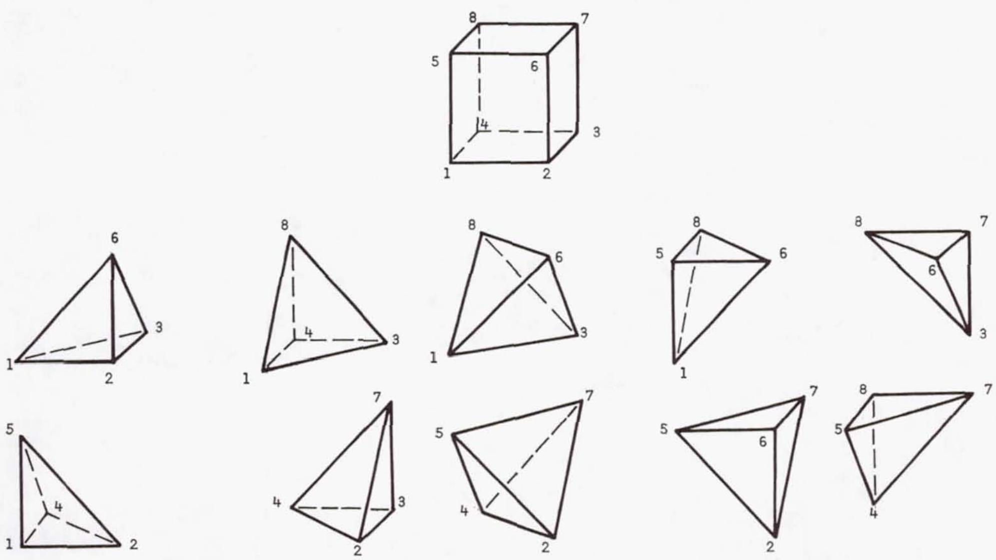
Figure 12. - Polyhedron elements and their subtetrahedra.



(a) Tetrahedron.



(b) Wedge and One of its Six Decompositions.



(c) Hexahedron and its Two Decompositions.

Figure 12. - Polyhedron elements and their subtetrahedra.

1.4 CONSTRAINTS AND PARTITIONING

Structural matrices are initially assembled in terms of all structural grid points, which excludes only the extra scalar points introduced for dynamic analysis. These matrices are generated with six degrees of freedom for each geometric grid point and a single degree of freedom for each scalar point. Various constraints are applied to these matrices in order to remove undesired singularities, provide boundary conditions, define rigid elements, and provide other desired characteristics for the structural model.

There are two basic kinds of constraints. Single-point constraints are used to constrain a degree of freedom to zero or to a prescribed value, and multipoint constraints are used to constrain a degree of freedom to be equal to a linear combination of the values of other degrees of freedom. The following four types of bulk data cards are provided for the definition of constraints:

1. Single-point constraint cards
2. Multipoint constraint cards
3. Cards to define reaction points on free bodies
4. Cards to define the omitted coordinates in matrix partitioning

The latter type does not produce constraint forces in static analysis.

1.4.1 Single-Point Constraints

A single-point constraint applies a fixed value to a translational or rotational component at a geometric grid point or to a scalar point. One of the most common uses of single-point constraints is to specify the boundary conditions of a structural model by fixing the appropriate degrees of freedom. Multiple sets of single-point constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. This procedure is particularly useful in the solution of problems having one or more planes of symmetry.

The elements connected to a grid point may not provide resistance to motion in certain directions, causing the stiffness matrix to be singular. Single-point constraints are used to remove these degrees of freedom from the stiffness matrix. A typical example is a planar structure composed of membrane and extensional elements. The translations normal to the plane and all three rotational degrees of freedom must be constrained since the corresponding stiffness matrix

terms are all zero. If a grid point has a direction of zero stiffness, the single-point constraint need not be exactly in that direction, but only needs to have a component in that direction. This allows the use of single-point constraints for the removal of such singularities regardless of the orientation of the global coordinate system. Although the displacements will depend on the direction of the constraint, the internal forces will be unaffected.

One of the tasks performed by the Structural Matrix Assembler (Section 4.27 of the Programmer's Manual) is to examine the stiffness matrix for singularities at the grid point level. Singularities remaining at this level, following the application of the single-point constraints, are listed in the Grid Point Singularity Table (GPST). This table is automatically printed following the comparison of the possible singularities tabulated by the Structural Matrix Assembler with the single-point constraints and the dependent coordinates of the multipoint constraint equations provided by the user. The GPST contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. These remaining singularities are treated only as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints in which these singularities are associated with independent coordinates.

Single-point constraints are defined on SPC, SPC1, SPCADD and SPCAX cards. The SPC card is the most general way of specifying single-point constraints. The SPC1 card is a less general card that is more convenient when a number of grid points have the same components constrained to a zero displacement. The SPCADD card defines a union of single-point constraint sets specified with SPC or SPC1 cards. The SPCAX card is used only for specifying single-point constraints in problems using conical shell elements.

Single-point constraints can also be defined on the GRID card. In this case, however, the constraints are part of the model and modifications cannot be made at the subcase level. Also, only zero displacements can be specified on the GRID card.

1.4.2 Multipoint Constraints

Each multipoint constraint is described by a single equation that specifies a linear relationship for two or more degrees of freedom. Multiple sets of multipoint constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. Multipoint constraints are

discussed in Sections 3.5.1 and 5.4 of the Theoretical Manual.

Multipoint constraints are defined on MPC, MPCADD and MPCAX cards. The MPC card is the basic card for defining multipoint constraints. The first coordinate mentioned on the card is taken as the dependent degree of freedom, i.e. that degree of freedom that is removed from the equations of motion. Dependent degrees of freedom may appear as independent terms in other equations of the set, however, they may appear as dependent terms in only a single equation. The MPCADD card defines a union of multipoint constraint sets specified with MPC cards. The MPCAX card is used only for specifying multipoint constraints in problems using conical shell elements. Some uses of multipoint constraints are:

1. To enforce zero motion in directions other than those corresponding with components of the global coordinate system. In this case, the multipoint constraint will involve only the degrees of freedom at a single grid point. The constraint equation relates the displacement in the direction of zero motion to the displacement components in the global system at the grid point.
2. To describe rigid elements and mechanisms such as levers, pulleys and gear trains. In this application, the degrees of freedom associated with the rigid element that are in excess of those needed to describe rigid body motion are eliminated with multipoint constraint equations. Treatment of very stiff members as being rigid elements eliminates the ill-conditioning associated with their treatment as ordinary elastic elements.
3. To be used with scalar elements to generate nonstandard structural elements and other special effects.
4. To describe parts of a structure by local vibration modes. This application is treated in section 14.1 of the Theoretical Manual. The general idea is that the matrix of local eigenvectors represents a set of constraints relating physical coordinates to modal coordinates.

At present, the user provides the coefficients in the multipoint constraint equations.

1.4.3 Free Body Supports

In the following discussion, a free body is defined as a structure that is capable of motion without internal stress, i.e. it has one or more rigid body degrees of freedom. The stiffness matrix for a free body is singular with the defect equal to the number of stress-free, or rigid

body modes. A solid three-dimensional body has up to six rigid body modes. Linkages and mechanisms can have a greater number. No restriction is placed in the program on the number of stress-free modes, in order to permit the analysis of mechanisms.

Free-body supports are defined with a SUPØRT card. In the case of problems using conical shell elements, the SUPAX card is used. In either case, only a single set can be specified, and if such cards appear in the Bulk Data Deck, they are automatically used in the solution. Free-body supports must be defined in the global coordinate system.

In static analysis by the displacement method, the rigid body modes must be restrained in order to remove the singularity of the stiffness matrix. The required constraints may be supplied with single-point constraints, multipoint constraints, or free-body supports. If free-body supports are used, the rigid body characteristics will be calculated and a check will be made on the sufficiency of the supports. Such a check is obtained by calculating the rigid body error ratio as defined in the Rigid Body Matrix Generator operation in Section 3.2.2. This error ratio is automatically printed following the execution of the Rigid Body Matrix Generator. The error ratio should be zero, but may be nonzero for any of the following reasons:

1. Round-off error accumulation
2. Insufficient free-body supports have been provided
3. Redundant free-body supports have been provided

The redundancy of the supports may be caused by improper use of the free-body supports themselves, or by the presence of single-point or multipoint constraints that constrain the rigid body motions.

Static analysis with inertia relief is necessarily made on a model having at least one rigid body motion. Such rigid body motion must be constrained by the use of free-body supports. These supported degrees of freedom define a reference system, and the elastic displacements are calculated relative to the motion of the support points. The element stresses and forces will be independent of any valid set of supports.

Rigid body vibration modes are calculated by a separate procedure provided that a set of free-body supports are supplied by the user. This is done to improve efficiency and, in some cases, reliability. The determinant method, for example, has difficulty extracting zero frequency roots of high multiplicity, whereas the alternate procedure of extracting rigid body modes is both efficient and reliable. If the user does not specify free-body supports (or he specifies

an insufficient number of them) the (remaining) rigid body modes will be calculated by the method selected for the finite frequency modes, provided zero frequency is included in the range of interest. If the user does not provide free-body supports, and if zero frequency is not included in the range of interest, the rigid body modes will not be calculated.

Free-body supports must be specified if the mode acceleration method of solution improvement is used for dynamics problems having rigid body degrees of freedom (see Section 9.4 of the Theoretical Manual). This solution improvement technique involves a static solution, and although the dynamic solution can be made on a free-body, the static solution cannot be performed without removing the singularities in the stiffness matrix associated with the rigid body motions.

1.4.4 Partitioning

A two-way partitioning scheme is provided as an optional feature for the NASTRAN model. The partitions are defined by listing the degrees of freedom for one of the partitions on the ØMIT card. These degrees of freedom are referred to as the omitted set. The remaining degrees of freedom are referred to as the analysis set. The ØMIT1 Card is easier to use if a large number of grid points have the same degrees of freedom in the omitted set. The ASET or ASET1 cards can be used to place degrees of freedom in the analysis set with the remaining degrees of freedom being placed in the omitted set. This is easier if the omitted set is large. In the case of problems using conical shell elements, the ØMITAX card is used.

Partitioning can be used to improve the efficiency in the solution or ordinary statics problems where the bandwidth of the unpartitioned stiffness matrix is large enough to cause excessive use of secondary storage devices during the triangular decomposition of the stiffness matrix. In this application, the analysis set should be relatively small and should be selected so that the omitted set will consist of uncoupled partitions, each having a bandwidth of approximately the same size and smaller than the original matrix. The omitted set might be thought of as consisting of several substructures which are coupled to the analysis set.

Matrix partitioning also improves efficiency when solving a number of similar cases with stiffness changes in local regions of the structure. In this application, the omitted set is relatively large, and should be selected so that the structural elements that will be changed are connected only to points in the analysis set. The stiffness matrix for the omitted set is then unaffected by the structural changes, and only the smaller stiffness matrix for the analysis set

need be decomposed for each case. In order to avoid repeating the decomposition of the stiffness matrix for the omitted set, the alter feature must be used to replace the functional module SMP1 with SMP2. The alter feature is described in section 2.2, and a similar use of SMP2 occurs near the end of the DMAP sequence used in the rigid format for Static Analysis with Differential Stiffness.

One of the more important applications of partitioning is the Guyan Reduction, described in Section 3.5.4 of the Theoretical Manual. This technique is a means for reducing the number of degrees of freedom used in dynamic analysis with minimum loss of accuracy. Its basis is that many fewer grid points are needed to describe the inertia of a structure than are needed to describe its elasticity with comparable accuracy. The error in the approximation is small provided that the set of displacements used for dynamic analysis is judiciously chosen. Its members should be uniformly dispersed throughout the structure and all large mass items should be connected to grid points that are members of the analysis set.

The user is cautioned to consider the fact that the matrix operations associated with this partitioning procedure tend to create nonzero terms and to fill what were previously very sparse matrices. The partitioning option is most effectively used if the members of the omitted set are either a very large fraction or a very small fraction of the total set. In most of the applications the omitted set is a large fraction of the total and the matrices used for analysis, while small, are usually full. If the analysis set is not a small fraction of the total, a solution using the larger, but sparser matrices, may well be more efficient. The partitioning option can also be used to make modest reductions in the order of the problem by placing a few scattered grid points in the omitted set. If the points in the omitted set are uncoupled, the sparseness in the matrices will be well preserved.

1.5 APPLIED LOADS

1.5.1 Static Loads

In NASTRAN, static loads are applied to geometric and scalar grid points in a variety of ways, including:

1. Loads applied directly to grid points.
2. Pressure on surfaces.
3. Gravity loads (internally generated).
4. Centrifugal forces due to steady rotation.
5. Equivalent loads resulting from thermal expansion
6. Equivalent loads resulting from enforced deformations of structural elements.
7. Equivalent loads resulting from enforced displacements of grid points.

Additional information on static loads is given in Section 3.6 of the Theoretical Manual. Any number of load sets can be defined in the Bulk Data Deck. However, only those sets selected in the Case Control Deck, as described in Section 2.3, will be used in the problem solution. The manner of selecting each type of load is specified on the associated bulk data card description in Section 2.4.

The FØRCE card is used to define a static load applied to a geometric grid point in terms of components defined by a local coordinate system. The orientation of the load components depends on the type of local coordinate system used to define the load. The directions of the load components are the same as those indicated on Figure 1 of Section 1.2 for displacement components. The FØRCE1 card is used if the direction is determined by a vector connecting two grid points, and a FØRCE2 card is used if the direction is specified by the cross product of two such vectors. The MØMENT, MØMENT1 and MØMENT2 cards are used in a similar fashion to define the application of a concentrated moment at a geometric grid point. The SLØAD card is used to define a load at a scalar point. In this case, only the magnitude is specified, as only one component of motion exists at a scalar point.

The FØRCEAX and MØMAX cards are used to define the loading of specified harmonics on rings of conical shell elements. FØRCE and MØMENT cards may be used to apply concentrated loads or moments to conical shell elements, providing that such points have been defined with a PØINTAX card.

Pressure loads on triangular and quadrilateral elements are defined with a PLØAD2 card. The positive direction of the loading is determined by the order of the grid points on the element connection card, using the right hand rule. The magnitude and direction of the load is automatically computed from the value of the pressure and the coordinates of the connected grid points. The load is applied to the connected grid points. The PLØAD card is used in a similar fashion to define the loading of any three or four grid points regardless of whether they are connected with two-dimensional elements. The PRESAX card is used to define a pressure loading on a conical shell element.

The GRAV card is used to specify a gravity load by providing the components of the gravity vector in any defined coordinate system. The gravity load is obtained from the gravity vector and the mass matrix assembled by the Structural Matrix Assembler (see Section 4.28 of the Programmer's Manual). The gravitational acceleration is not calculated at scalar points. The user is required to introduce gravity loads at scalar points directly.

The RFØRCE card is used to define a static loading condition due to a centrifugal force field. A centrifugal force load is specified by the designation of a grid point that lies on the axis of rotation and by the components of rotational velocity in any defined coordinate system. In the calculation of the centrifugal force, the mass matrix is regarded as pertaining to a set of distinct rigid bodies connected to grid points. Deviations from this viewpoint, such as the use of scalar points or the use of mass coupling between grid points, can result in errors.

Temperatures may be specified for selected elements. The temperatures for a RØD, BAR, CØNRØD or TUBE element are specified on the TEMPRB data card. This card specifies the average temperature on both ends and, in the case of the BAR element, is used to define temperature gradients over the cross section. Temperatures for two dimensional plate and membrane elements are specified on a TEMPP1, TEMPP2, or TEMPP3 data card. The user defined average temperature over the volume is used to produce in-plane loads and stresses. Thermal gradients over the depth of the bending elements, or the resulting moments, may be used to produce bending loads and stresses.

If no thermal element data is given for an element, the temperatures of the connected grid points given on the TEMP, TEMPD, or TEMPAX cards are simply averaged to produce an average temperature for the element. The thermal expansion coefficients are defined on the material definition cards. Regardless of the type of thermal data, if the material coefficients for an

element are temperature-dependent by use of the MATTi card, they are always calculated from the "average" temperature of the element. The mere presence of a thermal field does not imply the application of a thermal load. A thermal load will not be applied unless the user makes a specific request in the Case Control Deck.

Enforced axial deformations can be applied to rod and bar elements. They are useful in the simulation of misfit and misalignment in engineering structures. As in the case of thermal expansion, the equivalent loads are calculated by separate subroutines for each type of structural

element, and are applied to the connected grid points. The magnitude of the axial deformation is specified on a DEFØRM card.

The equivalent loads resulting from enforced displacments of grid points are calculated by the program and added to the other applied loads. The magnitudes of the enforced displacements are specified on SPC cards (SPCAX in the case of conical shell problems) in the global coordinate system. The application of the load is automatic when the user selects the associated SPC set in the Case Control Deck.

The LØAD card in the Bulk Data Deck defines a static loading condition that is a linear combination of load sets consisting of loads applied directly to grid points, pressure loads, gravity loads and centrifugal forces. This card must be used if gravity loads are to be used in combination with loads applied directly to grid points, pressure loads or centrifugal forces. The application of the combined loading condition is requested in the Case Control Deck by selecting the set number of the LØAD combination.

It should be noted that the equivalent loads (thermal, enforced deformation and enforced displacement) must have unique set identification numbers and be separately selected in the Case Control Deck. For any particular solution, the total static load will be the sum of the applied loads (grid point loading, pressure loading, gravity loading and centrifugal forces) and the equivalent loads.

1.5.2 Frequency Dependent Loads

A discussion of frequency response calculations is given in Section 12.1 of the Theoretical Manual. The DLØAD card is used to define linear combinations of frequency dependent loads that are defined on RLØAD1 or RLØAD2 cards. The RLØAD1 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{A[C(f) + iD(f)]e^{i(\theta - 2\pi f\tau)}\right\}, \qquad (1)$$

where A is defined on a DAREA card, C(f) and D(f) are defined on TABLEDi cards, θ is defined on a DPHASE card, and τ is defined on a DELAY card. The RLØAD2 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}}\right\}, \qquad (2)$$

where A is defined on a DAREA card, B(f) and ϕ(f) are defined on TABLEDi cards, θ is defined on a

DPHASE card, and τ is defined on a DELAY card. The coefficients on the DAREA, DELAY and DPHASE cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

A discussion of random response calculations is given in Section 12.2 of the Theoretical Manual. The RANDPS card defines load set power spectral density factors for use in random analysis of the form

$$S_{jk}(f) = (X + iY)G(f) \quad , \tag{3}$$

where G(f) is defined on a TABRNDi card. The subscripts j and k define the subcase numbers of the load definitions. If the applied loads are independent, only the diagonal terms (j=k) need be defined. The RANDT1 card is used to specify the time lag constants for use in the computation of the autocorrelation functions.

1.5.3 Time Dependent Loads

A discussion of transient response calculations is given in Section 11 of the Theoretical Manual. The DLØAD card is used to define linear combinations of time dependent loads that are defined on TLØAD1 and TLØAD2 cards. The TLØAD1 card defines a time dependent load of the form

$$\{P(t)\} = \{AF(t - \tau)\} \quad , \tag{4}$$

where A is defined on a DAREA card, τ is defined on a DELAY card, and $F(t-\tau)$ is defined on a TABLEDi card. The TLØAD2 card defines a time dependent load of the form

$$\{P(t)\} = \begin{cases} \{0\} , & \tilde{t} < 0 \text{ or } \tilde{t} > T_2 - T_1 \\ \left\{A\tilde{t}^B e^{C\tilde{t}} \cos(2\pi f\tilde{t}+P)\right\}, & 0 < \tilde{t} < T_2 - T_1 \end{cases} \quad , \tag{5}$$

where $\tilde{t} = t - T_1 - \tau$ and A and τ are defined as above. The coefficients on the DAREA and DELAY cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

Nonlinear effects are treated as an additional applied load vector, for which the components are functions of the degrees of freedom. This additional load vector is added to the right side of the equations of motion and treated along with the applied load vector during numerical inte-

gration. It is required that the points to which the nonlinear loads are applied and the degrees of freedom on which they depend be members of the solution set, i.e., that they cannot be degrees of freedom eliminated by constraints. It is further required, that if a modal formulation is used, the points referenced by the nonlinear loads be members of the set of extra scalar points introduced for dynamic analysis.

At present, NASTRAN includes four different types of nonlinear elements. For a discussion of nonlinear elements see Section 11.2 of the Theoretical Manual. The NØLIN1 card defines a nonlinear load of the form

$$P_i(t) = S_i T(u_j) \tag{6}$$

where P_i is the load applied to u_i, S_i is a scale factor, $T(u_j)$ is a tabulated function defined with a TABLEDi card, and u_j is any permissible displacement component. The NØLIN2 card defines a nonlinear load of the form

$$P_i(t) = S_i \, u_j \, u_k \tag{7}$$

where u_j and u_k are any permissible pair of displacement components. They may be the same. The NØLIN3 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} S_i(u_j)^A , & u_j > 0 \\ 0 , & u_j \le 0 \end{cases} , \tag{8}$$

where A is an exponent. The NØLIN4 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} -S_i(-u_j)^A , & u_j < 0 \\ 0 , & u_j \ge 0 \end{cases} . \tag{9}$$

1.6 DYNAMIC MATRICES

The dynamic matrices are defined as the stiffness, mass and damping matrices used in either the direct or modal formulation of dynamics problems. The assembly of dynamics matrices is discussed in Section 9.3 of the Theoretical Manual. There are three general sources for the elements of the dynamic matrices.

1. Matrices generated by the Structural Matrix Assembler.
2. Direct input matrices.
3. Modal matrices obtained from real eigenvalue analysis.

The Structural Matrix Assembler generates stiffness terms from the following sources:

1. Structural elements defined on connection cards, e.g., CBAR and CRØD.
2. General elements defined on GENEL cards.
3. Scalar springs defined on CELASi cards.

The Structural Matrix Assembler generates mass terms from the following sources:

1. A 6x6 matrix of mass coefficients at a grid point defined on a CØNM1 card.
2. A concentrated mass element defined on a CØNM2 card in terms of its mass and moments of inertia about its center of gravity.
3. Structural mass for all elements, except plate elements without membrane stiffness, using the mass density on the material definition card.
4. Nonstructural mass for all elements specifying a value on the property card.
5. Scalar masses defined on CMASSi cards.

A discussion of inertia properties, including the Lumped Mass method and the Coupled Mass method are given in Section 5.5 of the Theoretical Manual. The Structural Matrix Assembler will use the Lumped Mass method for bars, rods and plates unless the PARAM card CØUPMASS (see Section 3.1.5) is used to request the Coupled Mass method.

The Structural Matrix Assembler generates damping terms from the following sources:

1. Viscous rod elements defined on CVISC cards.
2. Scalar viscous dampers defined on CDAMPi cards.
3. Element structural damping by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element.

In addition, uniform structural damping is provided by multiplying the stiffness matrix generated

in Structural Matrix Assembler by a damping factor that is specified by the user on the PARAM card G (see Section 3.1.5). This form of damping is not recommended for hydroelastic problems.

The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards). The terms of the direct input matrices may be associated either with grid points or with extra points introduced for dynamic analysis.

The modal matrices are obtained from real eigenvalue analysis using the stiffness and mass matrices generated by the Structural Matrix Assembler.

1.6.1 Direct Formulation

In the direct method of dynamic problem formulation, the degrees of freedom are simply the displacements at grid points. The dynamic matrices are assembled from the direct input matrices and the stiffness, mass and damping matrices generated by the Structural Matrix Assembler. The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards).

For frequency response analysis and complex eigenvalue analysis the complete dynamic matrices are:

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}], \tag{1}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] \quad , \tag{2}$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \quad , \tag{3}$$

where the subscripts dd indicate the solution set composed of the degrees of freedom remaining after all constraints have been applied and the extra scalar points introduced for dynamic analysis. The matrices K, B and M are the stiffness, damping and mass matrices respectively. The superscript 1 indicates the matrices generated by the Structural Matrix Assembler. The superscript 2 indicates the direct input matrices. The matrix $[K^4_{dd}]$ is a structural damping matrix obtained by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element. The matrix $[K^1_{dd}]$ is multiplied by the damping factor (g) to provide for uniform structural damping in cases where it is appropriate. The constant g is specified by the user on a PARAM card (see Section 3.1.5).

For transient response analysis the complete dynamic matrices are:

$$[K_{dd}] = [K^1_{dd}] + [K^2_{dd}] \quad , \tag{4}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] + \frac{g}{\omega_3}[K^1_{dd}] + \frac{1}{\omega_4}[K^4_{dd}] \quad , \tag{5}$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \quad , \tag{6}$$

where ω_3 is the radian frequency at which the term $\frac{g}{\omega_3}[K^1_{dd}]$ produces the same magnitude of damping as the term $ig[K^1_{dd}]$ in frequency response analysis, and ω_4 is the radian frequency at which the term $\frac{1}{\omega_4}[K^4_{dd}]$ produces the same magnitude of damping as the term $i[K^4_{dd}]$ in frequency response analysis. The equivalent viscous damping is only an approximation to the structural damping as the viscous damping forces are larger at higher frequencies and smaller at lower frequencies. Therefore, the quantities ω_3 and ω_4 are frequently selected by the user to be at the center of the frequency range of interest. A small value of g/ω_3 is frequently useful to insure stability of higher modes in nonlinear transient analysis. The user specifies the values of ω_3 and ω_4 on PARAM cards W3 and W4 (see Section 3.1.5). If ω_3 and ω_4 are omitted, the corresponding terms are ignored.

1.6.2 Modal Formulation

In the modal method of dynamic problem formulation, the vibration modes of the structure in a selected frequency range are used as degrees of freedom, thereby reducing the number of degrees of freedom while maintaining accuracy in the selected frequency range. The frequency range is specified on PARAM cards by either selecting the number of lowest modes obtained from a real eigenvalue analysis or selecting all of the modes in a given frequency range (see Section 3.1.5).

It is important to have both direct and modal methods of dynamic problem formulation, in order to maximize efficiency in different situations. The modal method will usually be more efficient in problems where a small fraction of all of the modes are sufficient to produce the desired accuracy, provided that the bandwidth of the direct stiffness matrix is large. The bandwidth may be large due either to a compact structural arrangement or to dynamic coupling effects. The direct method will usually be more efficient for problems in which the bandwidth of the direct stiffness matrix is small and for problems with dynamic coupling in which a large

fraction of the vibration modes are required to produce the desired accuracy. For problems without dynamic coupling, i.e., for problems in which the matrices of the modal formulation are diagonal, the modal method will frequently be more efficient, even though a large fraction of the modes are needed.

The complete dynamic matrices used in dynamic analysis by the modal method include the direct input mass, damping and stiffness matrices $[M^2_{dd}]$, $[B^2_{dd}]$, $[K^2_{dd}]$, and the modal matrices $[m_i]$, $[b_i]$ and $[k_i]$, obtained from real eigenvalue analysis. The matrix $[m_i]$ is the modal mass matrix with off-diagonal terms (which should be zero) omitted. The modal damping matrix $[b_i]$ and stiffness matrix $[k_i]$ are obtained from $[m_i]$ by:

$$[b_i] = [2\pi f_i \; g(f_i) \; m_i] \quad , \tag{7}$$

$$[k_i] = [4\pi^2 \; f_i^2 \; m_i] \quad , \tag{8}$$

where f_i is the frequency of the i^{th} normal mode and $g(f_i)$ is obtained by interpolation of a table supplied by the user to represent the variation of structural damping with frequency. This table is defined with a TABDMP1 card. Structural damping will not be used in the modal formulation unless an SDAMPING card is used in the Case Control Deck to select a particular TABDMP1 card. The specification of damping properties for the modal method is somewhat less general than it is for the direct method, in that viscous dampers and nonuniform structural damping are not used.

The mode acceleration method of data recovery is optional when using the modal formulation for transient response and frequency response problems, see Section 9.4 of the Theoretical Manual for details. In this procedure, the inertia and damping forces are computed from the modal solution. These forces are then added to the applied forces and the combination is used to obtain a more accurate displacement vector for the structure by static analysis. This improved displacement vector is used in the stress recovery operation. The mode acceleration method is selected with the PARAM card MØDACC (see Section 3.1.5).

1.7 HYDROELASTIC MODELING

1.7.1 Solution of the NASTRAN Fluid Model

The NASTRAN hydroelastic option allows the user to solve a wide variety of fluid problems having structural interfaces, compressibility, and gravity effects. A complete derivation of the NASTRAN model and an explanation of the assumptions are given in the Theoretical Manual, Section 16.1. The input data and the solution logic have many similarities to a structural model. The standard normal modes analysis, transient analysis, complex eigenvalue analysis, and frequency response solutions are available with minor restrictions. The differences between a NASTRAN fluid model and an ordinary structural problem are due to the physical properties of a fluid, and are:

1. The independent degrees of freedom for a fluid are the Fourier coefficients of the pressure function (i.e. "harmonic pressures") in an axisymmetric coordinate system. The independent degrees of freedom for a structure are typically displacements and rotations at a physical point in space.

2. Much like the structural model, the fluid data will produce "stiffness" and "mass" matrices. Because they now relate pressures and flow instead of displacement and force, their physical meaning is quite different. The user may not apply loads, constraints, sequencing, or omitted coordinates "directly" on the fluid points involved. Instead, the user supplies information related to the boundaries and NASTRAN internally generates the correct constraints, sequencing, and matrix terms. Indirect methods, however, are available to the user for utilizing the internally generated points as normal grid or scalar points. See Section 1.7.4 for the identification code.

3. When a physical structure is to be connected to the fluid, the user supplies a list of fluid points and a related list of special structural grid points. NASTRAN will produce unsymmetric matrix terms which define the actual physical relations. A special provision is included in NASTRAN in the event that the structure has planes of symmetry. The user may, if he wishes, define only a section of the boundary and solve his problem with symmetric or antisymmetric constraints. The fluid-structure interface will take the missing sections of structural boundary into account.

4. Because of the special nature of the fluid problems, various user convenience options are absent. The fluid elements and harmonic pressures may not be included in the structural plots at present. Plotting the harmonic pressures versus frequency or time may not be "directly" requested. Because mass matrix terms are automatically generated if compressibility or free surface effects are present, the weight and C.G. calculations with fluid elements present may not be correct and should be avoided. Also, the inertia relief rigid format uses the mass matrix to produce internal loads and if fluids are included, these special fluid terms in the mass matrix may produce erroneous results.

In spite of the numerous differences between a NASTRAN structural model and a NASTRAN fluid model, the similarities allow the user to formulate a model with a minimum of data preparation and obtain efficient solutions to large order problems. The similarities of the fluid model to the NASTRAN structural model are:

1. The fluid is described by points in space and finite element connections. The locations of the axisymmetric fluid points are described by rings (RINGFL) about a polar axis, much like the axisymmetric conical shell. The rings are connected by elements (CFLUIDi) which have the properties of density and bulk modulus of compressibility. Each fluid ring produces, internally, a series of NASTRAN scalar points, P^n and P^{n*} (i.e. "harmonic pressures"), describing the pressure function, $P(\phi)$, in the following equation:

$$P(\phi) = P^o + \sum_{n=1}^{N} P^n \cos n\phi + \sum_{n=1}^{N} P^{n*} \sin n\phi \qquad 0 < N < 100$$

where the set of harmonics 0, n and n* are selected by the user. If the user desires the output of pressure at specific points on the circular ring, he may specify them as "pressure points" (PRESPT) by giving a point number and an angle on a specified fluid ring. The output data will have the values of pressure at the angle, ϕ, given in the above equation. The output of free surface displacements normal to the surface (FREEPT) are also available at specified angles, ϕ. The case control card option "AXISYM=FLUID" is necessary when any harmonic fluid degrees of freedom are included.

2. The input data to NASTRAN may include all of the existing options except the axisymmetric structural element data. All of the existing case control options may be included with some additional fluid case control requests. All of the structural element and constraint

data may be used (but not connected to RINGFL, PRESPT, or FREEPT fluid points). The structure-fluid boundary is defined with the aid of special grid points (GRIDB) which may be used for any purpose that a structural grid point is presently used.

3. The output data options for the structural part of a hydroelastic model are unchanged from the existing NASTRAN options. The output values for the fluid will be produced in the same form as the displacement vectors but with format modifications for the harmonic data. Printed values for the fluid may include both real and complex values. Pressures and free surface displacements, and their velocities and accelerations, may be printed with the same request (the case control request PRESSURE=SET is equivalent to DISP=SET) as structural displacements, velocities and accelerations. Structural plots are restricted to GRID and GRIDB points and any elements connected to them. X-Y plot and Random Analysis capability are available for FREEPT and PRESPT points if they are treated as scalar points. The RINGFL point identification numbers may not be used in any plot request, instead the special internally generated points used for harmonics may be requested in X-Y plots and Random Analysis. See Section 1.7.4 for the identification number code. No element stress or force data is produced for the fluid elements. As in the axisymmetric conical shell problem the case control request HARMØNICS=N is used to select up to the Nth harmonic for output.

1.7.2 Hydroelastic Input Data

A number of special NASTRAN data cards are required for fluid analysis problems. These cards are compatible with structural NASTRAN data. The NASTRAN RESTART feature will be available in Rigid Format Series M for changes in these data cards. A brief description of the uses for each bulk data card follows.

AXIF

This card controls the formulation of the axisymmetric fluid problem. It is a required card if any of the subsequent fluid related cards are present. The data references a fluid related coordinate system to define the axis of symmetry. The gravity parameter is included on the card rather than on the GRAV card because the direction of gravity must be parallel to the axis of symmetry. The values of density and bulk elastic modulus are conveniences in the event that these properties are constant throughout the fluid. A list of harmonics and the request for the nonsym-

metric (sine) coefficients are included on this card to allow the user to select any of the harmonics without producing extra matrix terms for the missing harmonics. A change in this list, however, will require a RESTART at the beginning of the problem.

RINGFL

The geometry of the fluid model about the axis of symmetry is defined with the aid of these data cards. The RINGFL data cards serve somewhat the same function for the fluid as the GRID cards serve in the structural model. In fact, each RINGFL card will produce, internally, a special grid point for each of the various harmonics selected on the AXIF data card. They may not, however, be connected directly to normal NASTRAN structural elements (see GRIDB and BDYLIST data cards). No constraints may be applied directly to RINGFL fluid points.

CFLUIDi

The data on these cards are used to define a volume of fluid bounded by the referenced RINGFL points. The volume is called an element and logically serves the same purpose as a structural finite element. The physical properties (density and bulk modulus) of the fluid element may be defined on this card if they are variables with respect to the geometry. If a property is not defined, the default value on the AXIF card is assumed. Two connected circles (RINGFL) must be used to define fluid elements adjacent to the axis of symmetry. A choice of three or four points is available in the remainder of the fluid.

GRIDB

This card provides an alternate to the GRID card for the definition of structural grid points. It also identifies the structural grid point with a particular RINGFL fluid point for hydroelastic problems. The particular purpose for this card is to force the user to place structural boundary points in exactly the same locations as the fluid points on the boundary. The format of the GRIDB card is identical to the format of the GRID card except that one additional field is used to identify the RINGFL point. The GRDSET card, however, is not used for GRIDB data.

If the user desires, he may use GRIDB cards without a fluid model. This is convenient in case the user wished to solve his structural problem first and to add the fluid effects later without converting GRID cards to GRIDB cards. The referenced RINGFL point must still be included in a boundary list (BDYLIST), see below, and the AXIF card must always be present when GRIDB cards are used. (The fluid effects are eliminated by specifying no harmonics.)

FREEPT, PRESPT

These cards are used to define points on a free surface for surface displacement output and points in the fluid for pressure output. No constraints may be applied to these points. Scalar elements and direct matrix data may be connected to these points, but the physical meaning of the elements will be different than in the structural sense.

FSLIST, BDYLIST

The purpose for these cards is to allow the user to define the boundaries of the fluid with a complete freedom of choice. The FSLIST card defines a list of fluid points which lie on a free surface. The BDYLIST data is a list of fluid points to which structural GRIDB points are connected. Points on the boundary of the fluid for which BDYLIST or FSLIST data are not defined are assumed to be rigidly restrained from motion in a direction normal to the surface.

With both of these lists the sequence of the listed points determines the nature of the boundary. The following directions will aid the user in producing a list.

1. Draw the z axis upward and the r axis to the right. Plot the locations of the fluid points on the right hand side of z.

2. If one imagines himself traveling along the free surface or boundary with the fluid on his right side the sequence of points encountered is used for the list. If the surface or boundary touches the axis, the word "AXIS" is placed in the list. "AXIS" may be used only for the first and/or last point in the list.

3. The free surface must be consistent with static equilibrium. With no gravity field, any free surface consistent with axial symmetry is allowed. With gravity, the free surface must be a plane perpendicular to the z axis of the fluid coordinate system.

4. Multiple free surface lists and boundary lists are allowed. A fluid point may be included in any number of lists.

Figure 1.7-1 illustrates a typical application of the free surface and structural boundary lists.

FLSYM

This card allows the user to optionally model a portion of the structure with planes of symmetry containing the polar axis of the fluid. The first plane of symmetry is assumed at

$\phi = 0.0$ and the second plane of symmetry is assumed at $\phi = 360°/M$ where M is an integer specified on the card. Also specified are the types of symmetry for each plane, symmetric (S) or antisymmetric (A). The user must also supply the relevant constraint data for the structure. The solution is performed correctly only for those harmonic coefficients that are compatible with the symmetry conditions as illustrated in the following example for quarter symmetry, M = 4.

Series	Plane 1	Plane 2	
		S	A
Cosine	S	0,2,4,...	1,3,5,...
	A	none	none
Sine	S	none	none
(*)	A	1,3,5,...	2,4,6,...

<u>DMIAX</u>

These cards are used for Direct Matrix Input for special purposes such as surface friction effects. They are equivalent to the DMIG cards, the only difference being the capability to specify the harmonic numbers for the degrees of freedom. A matrix may be defined with either DMIG or DMIAX cards, but not with both.

1.7.3 Rigid Formats

The characteristics of the fluid analysis problems which cause restrictions on the type of solution are:

1. The fluid-structure interface is mathematically described by a set of unsymmetric matrices. Since the first six Rigid Formats are restricted to the use of symmetric matrices, the fluid-structure boundary is ignored. Thus, for any of these Rigid Formats the program solves the problem for a fluid in a rigid container with an optional free surface and an uncoupled elastic structure with no fluid present.

2. No means are provided for the direct input of applied loads on the fluid. The only direct means of exciting the fluid is through the structure-fluid boundary. The fluid problem may be formulated in any rigid format. However, only some will provide nontrivial solutions.

The suggested Rigid Formats for the axisymmetric fluid and the restrictions on each are described below:

Rigid Format No. 3 - Normal Modes Analysis

The modes of a fluid in a rigid container may be extracted with a conventional solution request. Free surface effects with or without gravity may be accounted for. Any structure data in the deck will be treated as a disjoint problem. (The structure may also produce normal modes.) Normalization of the eigenvectors using the PØINT option will cause a fatal error.

Rigid Format No. 7 - Direct Complex Eigenvalue Analysis

The coupled modes of the fluid and structure must be solved with this rigid format. If no damping or direct input matrices are added, the resulting complex roots will be purely imaginary numbers, whose values are the natural frequencies of the system. The mode shape of the combination may be normalized to the maximum quantity (harmonic pressure or structural displacement) or to a specified structural point displacement.

Rigid Format No. 8 - Direct Frequency and Random Response

This solution may be used directly if the loads are applied only to the structural points. The use of overall structural damping (parameter g) is not recommended since the fluid matrices will be affected incorrectly. Output restrictions are listed on page 1.7-3.

Rigid Format No. 9 - Direct Transient Response

Transient analysis may be performed directly on the fluid-structure system if the following rules apply.

1. Applied loads and initial conditions are only given to the structural points.
2. All quantities are measured relative to static equilibrium. The initial values of the pressures are assumed to be at equilibrium.
3. Overall structural damping (parameters ω_3 and g) must not be used.
4. Output restrictions are listed on page 1.7-3.

Rigid Formats 10, 11, and 12 - Modal Formulations

Although these rigid formats may be used in a fluid dynamics problem, their practicality is limited. The modal coordinates used to formulate the dynamic matrices will be the normal modes of both the fluid and the structure solved as uncoupled systems. Even though the range of natural frequencies would be typically very different for the fluid than for the structure, NASTRAN will select both sets of modes from a given fixed frequency range. The safest method with the present system is the extraction of all modes for both systems with the Tridiagonalization Method. This procedure, however, results in a dynamic system with large full matrices. The Direct Formulation would be more efficient in that case. At present, the capability for fluid-structure boundary coupling is not provided with Rigid Formats 10, 11 and 12. However the capability may be provided by means of an ALTER using the same logic as in the direct formulations.

1.7.4 Hydroelastic Data Processing

The fluid related data cards submitted by the user are processed by the NASTRAN preface module to produce equivalent grid point, scalar point, element connection, and constraint data card images. Each specified harmonic, N, of the Fourier series solution produces a complete set of special grid and connection card images. In order to retain unique identification numbers the user identification numbers are encoded by the algorithm below:

RINGFL points:

NASTRAN grid Id. = User ring Id. + 1,000,000 x I_N

where

I_N = N + 1 cosine series

I_N = N + 1/2 sine series

CFLUIDi connection cards:

NASTRAN element Id. = User element Id. x 1000 + I_N

where I_N is defined above for each harmonic N.

For example, if the user requested all harmonics from zero to two, including the sine(*) series, each RINGFL card will produce five special grid cards internally. If the user's Identifi-

cation number (in field 2 of the RINGFL data card) were 37, the internally generated grid points would have the following identification numbers:

Harmonic	Id.
0	1,000,037
1*	1,500,037
1	2,000,037
2*	2,500,037
2	3,000,037

These equivalent grid points are resequenced automatically by NASTRAN to be adjacent to the original RINGFL identification number. A RINGFL point may not be resequenced by the user.

The output from matrix printout, table printout, and error messages will have the fluid points labeled in this form. If the user wishes, he may use these numbers as scalar points for Random Analysis, X-Y plotting, or for any other purpose.

In addition to the multiple sets of points and connection cards, the NASTRAN preface also may generate constraint sets. For example if a free surface (FSLIST) is specified in a zero-gravity field, the pressures are constrained by NASTRAN to zero. For this case the internally generated set of single point constraints are internally combined with any user defined structural constraints and will always be automatically selected.

If pressures at points in the fluid (PRESPT) or gravity dependent normal displacements on the free surface (FREEPT) are requested, the program will convert them to scalar points and create a set of multipoint constraints with the scalar points as dependent variables. The constraint set will be internally combined with any user defined sets and will be selected automatically.

The PRESPT and FREEPT scalar points may be used as normal scalar points for purposes such as plotting versus frequency or time. Although the FREEPT values are displacements, scalar elements connected to them will have a different meaning than in the structural sense.

1.7.5 Sample Hydroelastic Model

Table 1.7-1 contains a list of the data deck for a sample hydroelastic problem. Figure 1.7-2 describes the problem and lists the parameters. The relatively small number of grid points were chosen for purposes of simplicity, and not accuracy. The special cards for hydroelastic analysis are flagged with the symbol (†). The symbols for the fields in the hydroelastic data cards are

placed above each group. Structural data cards are included in their standard formats. The explanations for the data are given in the following notes:

1. Rigid Format Series M will not require the ALTER PACKAGE. The additional DMAP instructions are documented in Section 3 for Rigid Format Series L.

2. The "AXISYM=FLUID" card is necessary to control the constraint set selections and the output formats for a fluid problem. It must appear above the subcase level.

3. "DISPLACEMENT=" and "PRESSURE=" case control cards are pseudonyms. "DISP=ALL" will produce all structure displacements, free surface displacements, and all fluid pressure values in the output. The "HARMØNICS=" control is a limit on the harmonic data and has the same function as in an axisymmetrical conical shell problem.

4. The AXIF card defines the existence of a hydroelastic problem. It is used to define overall parameters and control the harmonic degrees of freedom.

5. The RINGFL cards included will define the five points on the fluid cross section.

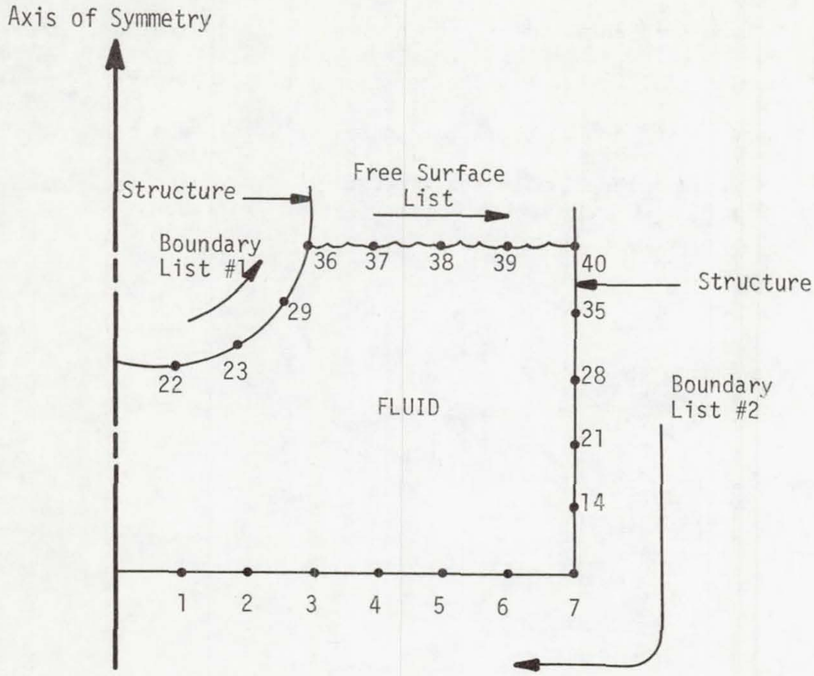
6. The CFLUIDi cards are used to define the volume of the fluid as finite elements connected by the RINGFL points. Since parameters ρ and B are missing, the default values on the AXIF card will be used.

7. The FSLIST card is used to define the free surface at $z = 10.0$. The density factor, ρ, is placed on the card in this case. If blank, the default value on the AXIF card is used.

8. The fluid-structure boundary is defined on the BDYLIST card. The AXIF default density is used.

9. The GRIDB cards define the structure points on the fluid boundary. Points #3 through #6 are connected to the #2 fluid ring. The rotation in the r direction ("4" in field 8) is constrained.

10. The fact that one-quarter symmetry was used for the structure requires the use of the FLSYM card. Symmetric-Antisymmetric boundaries indicate that only the cosine terms for the odd harmonics will interact with the structure. If Symmetric-Symmetric boundary conditions were chosen on the FLSYM data card, only the even harmonics of the cosine series would interact with the structure.

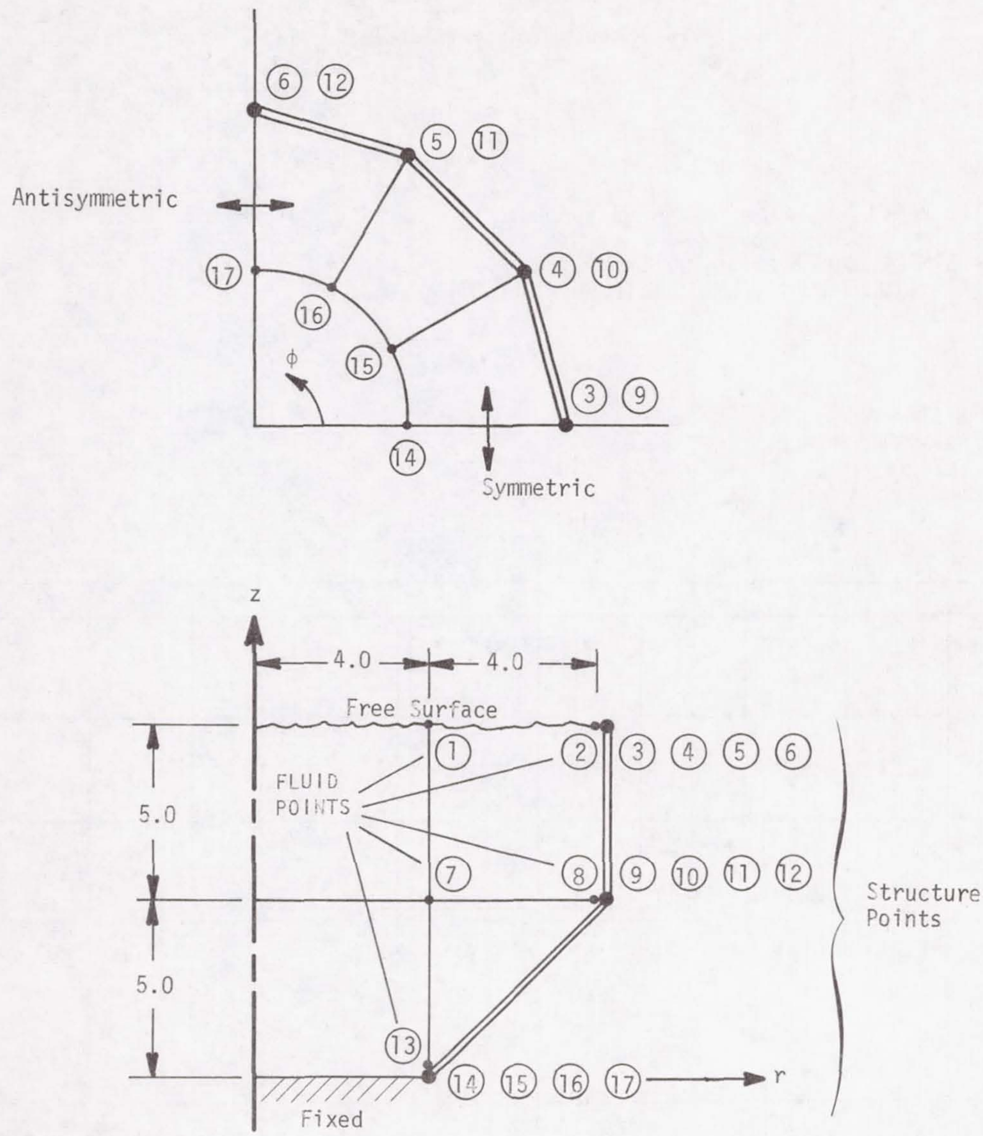


FSLIST: 36, 37, 38, 39, 40

BDYLIST #1: AXIS, 22, 23, 29, 36

BDYLIST #2: 40, 35, 28, 21, 14, 7, 6, 5, 4, 3, 2, 1, AXIS

Figure 1.7-1 Examples of boundary lists.



Fluid: Density, $\rho = 0.03$

Bulk Modulus, $B = \infty$

Gravity, $g = 32.2$

Structure: Thickness, $t = 0.5$

Density, $\rho = 0.05$

Figure 1.7-2 Sample hydroelastic problem.

Table 1.7-1 Sample hydroelastic problem.

```
     ID    HYDRØ, USER
     APP   DISP
     SØL   7,0
     TIME  2
  (†)(ALTER PACKAGE)                                                   (1)
     CEND
     TITLE = SAMPLE HYDRØELASTIC PRØBLEM.
     SUBTITLE = EIGENVALUE ANALYSIS WITH FLEXIBLE BØUNDARY.
  (†)AXISYM=FLUID                                                      (2)
     SPC = 3
     CMETHØD = 1
     ØUTPUT
            DISP = ALL
            HARMØNICS = ALL                                            (3)
            ELFØRCE = ALL
     BEGIN BULK
```

BULK DATA FIELD

	1	2	3	4	5	6	7	8	9	10	
		(CID)	(g)	(ρ)	(B)	(*SERIES?)					
(†)	AXIF	2	32.2	0.03		NØ				+AX	(4)
		(N_1)	(N_2)								
	+AX	1	3								
	CØRD2C	2		0.	0.	0.	0.	0.	1.0	+CØ	
	+CØ	1.0	0.	0.							
		(Id)	(r)		(z)	(Id)	(r)		(z)		
(†)	RINGFL	1	4.0		10.0	2	8.0		10.0		(5)
(†)	RINGFL	7	4.0		5.0	8	8.0		5.0		
(†)	RINGFL	13	4.0		0.0						
		(Id)	(f_1)	(f_2)	(f_3)	(f_4)	(ρ)	(B)			
(†)	CFLUID2	101	1	7							(6)
(†)	CFLUID2	102	7	13							
(†)	CFLUID3	103	7	8	13						
(†)	CFLUID4	104	1	2	7	8					
		(ρ)	(Id_1)	(Id_2)	(Id_3)						
(†)	FSLIST	0.03	AXIS	1	2						(7)
		(ρ)	(Id_1)	(Id_2)	(Id_3)						
(†)	BDYLIST		2	8	13						(8)

(Continued)

	1	2	3	4	5	6	7	8	9	10	
		(Id)			(ϕ)		(CID)	(P-SPC)	(IDF)		
(†)	GRIDB	3			0.0		2	4	2		(9)
	GRIDB	4			30.0		2	4	2		
	GRIDB	5			60.0		2	4	2		
	GRIDB	6			90.0		2	4	2		
	GRIDB	9			0.		2		8		
	GRIDB	10			30.		2		8		
	GRIDB	11			60.		2		8		
	GRIDB	12			90.		2		8		
	GRIDB	14			0.		2		13		
	GRIDB	15			30.		2		13		
	GRIDB	16			60.		2		13		
	GRIDB	17			90.		2		13		
	CQUAD2	10	11	3	9	10	4				
	CQUAD2	11	11	4	10	11	5				
	CQUAD2	12	11	5	11	12	6				
	CQUAD2	13	11	9	14	15	10				
	CQUAD2	14	11	10	15	16	11				
	CQUAD2	15	11	11	16	17	12				
	PQUAD2	11	12	0.5							
	MAT1	12	10.6+6		0.3	0.05					
	SPC1	3	246	3	9	14					
	SPC1	3	135	6	12	17					
	SPC1	3	135	14	15	16					
		(M)	(S1)	(S2)							
(†)	FLSYM	4	S	A							(10)
	EIGC	1	INV	MAX						+EI	
	+EI	0.	0.	0.	5.	3.	2	2			
	ENDDATA										

1.8 HEAT TRANSFER PROBLEMS

1.8.1 Introduction to NASTRAN Heat Transfer

NASTRAN heat flow capability may be used either as a separate analysis to determine temperatures and fluxes, or to determine temperature inputs for structural problems. Steady and transient problems can be solved, including heat conduction (with variable conductivity for static analysis), film heat transfer, and nonlinear (fourth power law) radiation.

The heat flow problem is similar, in many ways, to structural analysis. The same grid points, coordinate systems, elements, constraints, and sequencing can be used for both problems. There are several differences, such as the number of degrees of freedom per grid point, the methods of specifying loads, boundary film heat conduction, and the nonlinear elements. For heat flow problems, the only unknown at a grid point is the temperature (cf. structural analysis with three translations and three rotations), and hence, there is one degree of freedom per grid point. Additional grid or scalar points are introduced for ambient temperatures in film heat transfer. If the conductivity of an element is temperature dependent, the problem becomes nonlinear (cf. structural analysis with temperature dependent materials which only requires looking up material properties and computing thermal loads).

The heat conduction analysis of NASTRAN is compatible with structural analysis. If the same finite elements are appropriate, then the same grid and connection cards can be used for both problems. As in structural analysis, the choice of a finite element model is left to the analyst. Temperature distributions can be output in a format which can be input into structural problems. Heat flow analysis uses many structural NASTRAN bulk data cards. These include (where i means there is more than one type): CBAR, CDAMPi, CELASi, CHEXAi, CØNRØD, CØRDii, CQDMEM, CQDPLT, CQUADi, CRØD, CTETRA, CTRAPRG, CTRIAi, CTRIARG, CTRMEM, CTUBE, CVISC, CWEDGE, DAREA, DELAY, DLØAD, DMI, DMIG, EPØINT, GRDSET, GRID, LØAD, MPC, MPCADD, NØLINi, ØMITi, PARAM, Piii (for elements requiring properties), PLØTEL, SEQiP, SLØAD, SPCi, SPCADD,SPØINT, TABLEDi, TABLEMi, TEMPii, TF, TLØADi, and TSTEP.

1.8.2 Heat Transfer Elements

The basic heat conduction elements are the same as NASTRAN structural elements. These elements are shown in the following table:

Heat Conduction Elements	
Type	Elements
Linear	BAR, RØD, CØNRØD, TUBE
Membrane	TRMEM, TRIA1, TRIA2, QDMEM, QUAD1, QUAD2
Solid of Revolution	TRIARG, TRAPRG
Solid	TETRA, WEDGE, HEXA1, HEXA2

A connection card (Cxxx) and, if applicable, a property card (Pxxx) is defined for each of these elements. Linear elements have a constant cross-sectional area. The offset on the BAR is treated as a perfect conductor (no temperature drop). For the membrane elements, the heat conduction thickness is the membrane thickness. The bending characteristics of the elements do not enter into heat conduction problems. The solid of revolution element, TRAPRG, has been generalized to accept general quadrilateral rings (i.e., the top and bottom need not be perpendicular to the z-axis for heat conduction). These heat conduction elements are composed of constant gradient lines, triangles, and tetrahedra. The quadrilaterals are composed of overlapping triangles, and the wedges and hexahedra from subtetrahedra. Gradients and fluxes may be output by requesting ELFØRCE.

Thermal material conductivities and heat capacities are given on MAT4 (isotropic) and MAT5 (anisotropic) bulk data cards. Temperature dependent conductivities are given on MATT4 and MATT5 bulk data cards, which can only be used for nonlinear static analysis. The heat capacity per unit volume is specified, which is the product of density and heat capacity per unit mass (ρC_p).

A special element (HBDY) defines an area for boundary conditions. There are five basic types, called PØINT, LINE, REV, AREA3, and AREA4 (the sixth type, ELCYL, is for use only with QVECT radiation). The HBDY is considered an element, since it can add terms to the conduction and heat capacity matrices. There is a CHBDY connection and PHBDY property card. When a film heat transfer condition is desired, film conductivity and heat capacity per unit area are specified on MAT4

data cards. The ambient temperature is specified with additional points (GRID or SPØINT) listed on the CHBDY connection card. See Figure 1 for geometry.

Radiation heat exchange may be included between HBDY elements. A list of HBDY elements must be specified on a RADLST bulk data card. The emissivities are specified on the PHBDY cards. The Stefan-Boltzmann constant (SIGMA) and absolute reference temperature (TABS) are specified on PARAM bulk data cards. Radiation exchange coefficients (default is zero) are specified on RADMTX bulk data cards.

The several types of power input to the HBDY elements can be output by requesting "ELFØRCE".

1.8.3 Constraints and Partitioning

Constraints are applied to provide boundary conditions, represent "perfect" conductors, and provide other desired characteristics for the heat transfer model.

Single point constraints are used to specify the temperature at a point. The grid or scalar points are listed on SPC or SPC1 bulk data cards. The component on the data card can be "0" or "1". This declares the degree of freedom to be in the u_s set. The method of specifying temperature is dependent upon the problem type.

Algorithm	Value of u_s Used
Linear statics	Values defined on selected SPC cards.
Nonlinear statics	Values of the selected TEMP (MATERIAL) set.
Transient	u_s = 0.0 (special modeling techniques, such as a good conductor with a large power specified, can be used to enforce u(t)).

Multipoint constraints are linear relationships between temperatures at several grid points, and are specified on MPC cards. The first entry on an MPC card will be in the u_m set. The type of constraint is limited if nonlinear elements are present. If a member of set u_m touches a non-linear (conduction or radiation) element, the constraint relationship is restricted to be an "equivalence". The term "equivalence" means that the value of the member of the u_m set will be

equal to one of the members of the u_n set (a point not multipoint constrained). Those points not touching nonlinear elements are not so limited. The user will be responsible to satisfy the equivalence requirement, by having only two entries on the MPC data card, with equal (but opposite in sign) coefficients.

1.8.4 Thermal Loads

Thermal "loads" may be boundary heat fluxes or volume heat addition. As in the case of structural analysis, the method of specifying loads is different for static and transient analysis. The HBDY element is used for boundaries of conducting regions. Surface heat flux input can be specified for HBDY elements with QBDY1 and QBDY2 data cards. These two cards are for constant and (spatially) variable flux, respectively. Flux can be specified without reference to an HBDY element with the QHBDY data card. Vector flux, such as solar radiation, depends upon the angle between the flux and the element normal, and is specified for HBDY elements with the QVECT data card. This requires that the orientation of the HBDY element be defined. Volume heat addition into a conduction element is specified on a QVØL data card.

Static thermal loads are requested in case control with "LØAD" card. All of the above load types plus SLØAD's can be requested. Transient loads are requested in case control with a "DLØAD" card, which selects TLØAD time functions. Transient thermal loads may use DAREA (as in structural transient), and the QBDY1, QBDY2, QHBDY, QVECT, QVØL, and SLØAD cards.

1.8.5 Linear Static Analysis

Linear static analysis uses APProach HEAT, SØLution 1. The rigid format is the same as that used for static structural analysis. This implies that several loading conditions and constraint sets can be solved in one job, by using subcases in the Case Control Deck.

1.8.6 Nonlinear Static Analysis

Nonlinear static analysis uses APProach HEAT, SØLution 3. This rigid format will allow temperature dependent conductivities of the elements, nonlinear radiation exchange, and a limited use of multipoint constraints. There is no looping for load and constraints. The solution is iterative. The user can supply values on PARAM bulk data cards for:

MAXIT (integer)	Maximum number of iterations (default 4).
EPSHT (real)	ε convergence parameter (default .001).
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
IRES (integer)	Request residual vector output if positive (default -1).

The user must supply an estimate of the temperature distribution vector $\{u^1\}$. This estimate is used to calculate the reference conductivity plus radiation matrix needed for the iteration. $\{u^1\}$ is also used at all points in the u_s set to specify a boundary temperature. The values of $\{u^1\}$ are given on TEMP bulk data cards, and they are selected by TEMP(MATERIAL) in case control.

Iteration may stop for the following reasons:

1. Normal convergency: ε_T < EPSHT, where ε_T is the per unit error estimate of the temperatures calculated.
2. Number of iterations > MAXIT.
3. Unstable: $|\lambda_1| < 1$ and the number of iterations > 3, where λ_1 is a stability estimator.
4. Insufficient time to perform another iteration and output data.

The precise definitions are given in the NASTRAN Theoretical Manual, Section 8.4. Error estimates ε_p, λ_1, and ε_T for all iterations may be output with the Executive Control Card DIAG 18, where ε_p is the ratio of the Euclidian norms of the residual (error) loads to the applied loads on the unconstrained degrees of freedom.

1.8.7 Transient Analysis

Transient analysis uses APProach HEAT, SØLution 9. This rigid format may include conduction, film heat transfer, nonlinear radiation, and NASTRAN nonlinear elements. Extra points are used as in structural transient analysis. All points associated with nonlinear loads must be in the solution set. Loads may be applied with TLØAD and DAREA cards as in structural analysis. Also, the thermal static load cards can be modified by a function of time for use in transient analysis. Loads are requested in case control with DLØAD. Initial temperatures are specified on TEMP bulk data cards and are requested by IC. Previous static or transient solutions can be easily used as initial conditions, since they can be punched in the correct format. An estimate of the temperature $\{u^1\}$ is specified on TEMP bulk data cards for transient with radiation, and is requested by TEMP(MATERIAL). The parameters available are:

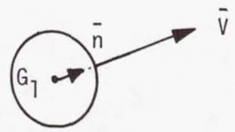
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
BETA (real)	Foreward difference integration factor (default .55).
RADLIN (integer)	Radiation is linearized if positive (default -1).

Time steps are specified on TSTEP data cards.

1.8.8 Compatibility with Structural Analysis

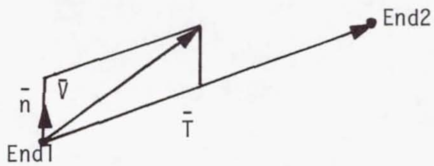
Grid point temperatures for thermal stress analysis (static structural analysis) are specified on TEMP bulk data cards. If punched output is requested in a heat conduction analysis, the format of the punched card is exactly that of a double field TEMP* data card. Thus, if the heat conduction model is the same as the structural model, the same grid, connection, and property cards can be used for both, and the temperature cards for the structural analysis are produced by the heat conduction analysis. The output request in case control is THERMAL(PUNCH).

Type = PØINT



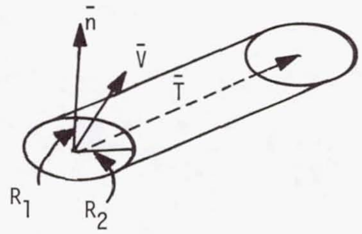
The unit normal vector is given by $\bar{n} = \bar{V}/|\bar{V}|$, where $\bar{V}$ is given in the basic system at the referenced grid point (see CHBDY data card, fields 16-18).

Type = LINE



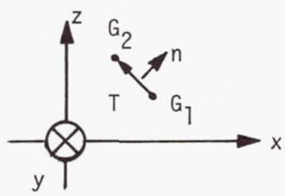
The unit normal lies in the plane of $\bar{V}$ and $\bar{T}$, is perpendicular to $\bar{T}$, and is given by $\bar{n} = (\bar{T} \times (\bar{V} \times \bar{T}))/|\bar{T} \times (\bar{V} \times \bar{T})|$.

Type = ELCYL



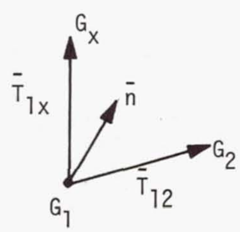
The same logic is used to determine $\bar{n}$ as for type = LINE. The "radius" R_1 is in the $\bar{n}$ direction, and R_2 is perpendicular to $\bar{n}$ and $\bar{T}$ (see fields 7 and 8 of PHBDY card).

Type = REV



The unit normal lies in the x-z plane, and is given by $\bar{n} = (\bar{e}_y \times \bar{T})/|\bar{e}_y \times \bar{T}|$. $\bar{e}_y$ is the unit vector in the y direction.

Type = AREA3 or AREA4



The unit normal vector is given by $\bar{n} = (\bar{T}_{12} \times \bar{T}_{1x})/|\bar{T}_{12} \times \bar{T}_{1x}|$, where x = 3 for triangles and x = 4 for quadrilaterals.

Figure 1. HBDY Element Orientation (for QVECT flux).

1.9 ACOUSTIC CAVITY MODELING

1.9.1 Data Card Functions

The NASTRAN structural analysis system is used as the basis for acoustic cavity analysis. Many of the structural analysis options such as selecting boundary conditions, applying loading conditions, and selecting output data are also available for acoustics.

The data cards specifically used for acoustic cavity analysis are described below. The card formats are exhibited in Section 2.4. Their purposes are analogous to the use of structural data cards. A gridwork of points is distributed over the longitudinal cross section of an acoustic cavity and finite elements are connected between these points to define the enclosed volume.

The points are defined by GRIDF data cards for the axisymmetric central fluid cavity and by GRIDS data cards for the radial slots. The GRIDF points are interconnected by finite elements via the CAXIF2, CAXIF3, and CAXIF4 data cards to define a cross sectional area of the body of rotation. The CAXIF2 element data card defines the area of the cross section between the axis and two points off the axis (the GRIDF points may not have a zero radius). The CAXIF3 and CAXIF4 data cards define triangular or quadrilateral cross sections and connect three or four GRIDF points respectively. The density and/or bulk modulus at each location of the enclosed fluid may also be defined on these cards.

The GRIDS points in the slot region are interconnected by finite elements via the CSLØT3 and CSLØT4 data cards. These define finite elements with triangular and quadrilateral cross-sectional shapes respectively. The width of the slot and the number of slots may be defined by default values on the AXSLØT data card. If the width of the slots is a variable, the value is specified on the GRIDS cards at each point. The number of slots, the density, and/or the bulk modulus of the fluid may also be defined individually, for each element on the CSLØT3 and CSLØT4 cards.

The AXSLØT data card is used to define the overall parameters for the system. Some of these parameters are called the "default" values and may be selectively changed at particular cross sections of the structure. The values given on the AXSLØT card will be used if a corresponding value on the GRIDS, CAXIFi, or CSLØTi is left blank. The parameters ρ (density) and B (bulk modulus) are properties of the fluid. If the value given for Bulk Modulus is zero the fluid is considered incompressible to the program. The parameters M (Number of slots) and W (slot width) are properties of the geometry. The parameter M defines the number of equally spaced slots

around the circumference with the first slot located at $\phi = 0°$. The parameter N (harmonic number) is selected by the user to analyze a particular set of acoustic modes. The pressure is assumed to have the following distribution

$$p(r,z,\phi) = p(r,z) \cos N\phi$$

If N = 0 the breathing and longitudinal modes will result. If N = 1 the pressure at $\phi = 180°$ will be the negative of the pressure at $\phi = 0°$. If N = 2, the pressures at $\phi = 90°$ and $\phi = 270°$ will be the negative of that at $\phi = 0°$. Values of N larger than M/2 have no significance.

The interface between the central cavity and the slots is defined with the SLBDY data cards. The data for each card consists of the density of the fluid at the interface, the number of radial slots around the circumference, and a list of GRIDS points that are listed in the sequence in which they occur as the boundary is traversed. In order to ensure continuity between GRIDF and GRIDS points at the interface, the GRIDF points on the boundary between the cylindrical cavity and the slots are identified on the corresponding GRIDS data cards rather than on GRIDF cards. Thus, the locations of the GRIDF points will be exactly the same as the locations of the corresponding GRIDS points.

Various standard NASTRAN data cards may be used for special purposes in acoustic analysis. The SPC1 data card may be used to constrain the pressures to zero at specified points such as at a free boundary. The formats for these cards are included in Section 2.4. Dynamic load cards, direct input matrices, and scalar elements may be introduced to account for special effects. The reader is referred to Sections 1.4 and 1.5 for instruction in the use of these cards.

1.9.2 Assumptions and Limitations

The accuracy of the acoustic model will be dependent on the selection of the mesh of finite elements. The assumption for each element is that the pressure field has a linear variation over the cross section and a sinusoidal variation around the axis in the circumferential direction. In areas where the pressure gradient changes are large, such as near a sharp corner, the points in the mesh should be placed closer together so that large changes in flow may be defined accurately by the finite elements.

The shape of the finite elements play an important part in the accuracy of the results. It has been observed that long narrow elements produce disproportionate errors. Cutting a large

square into two rectangles will not improve the results whereas dividing the square into four smaller squares may decrease the local error by as much as a factor of ten.

The slot portion of the cavity is limited to certain shapes because of basic assumptions in the algorithms. The cross section of the cavity normal to the axis must have a shape that is reasonably well defined by a central circular cavity having equally spaced, narrow slots. Various shapes are shown in Figure 1 in the order of increasing expected error.

It is recommended that shapes such as the cloverleaf and square cross section be analyzed with a full three dimensional technique. The assumption of negligible pressure gradient in the circumferential direction within a slot is not valid in these cases.

The harmonic orders of the solutions are also limited by the width of the slots. The harmonic number, N, should be no greater than the number of slots divided by two. The response of the higher harmonics is approximated by the slot width correction terms discussed in the NASTRAN Theoretical Manual, Section 17.1.

The output data for the acoustic analysis consists of the values of pressure in the displacement vector selected via the case control card "PRESSURE = i". The velocity vector components corresponding to each mode may be optionally requested by the case control card "STRESS = i", where i is the set number indicating the element numbers to be used for output, or by the words "STRESS = ALL". The "SET =" card lists the element or point numbers to be output.

Plots of the finite element model and/or of the pressure field may be requested with the NASTRAN plot request data cards. The central cavity cross section will be positioned in the XY plane of the Basic Coordinate System of NASTRAN. The slot elements are offset from the XY plane by the width of the slot in the +Z direction. The radial direction corresponds to X and the axial direction corresponds to the Y direction. Pressures will be plotted in the Z direction for both the slot points and the central cavity points. The case control data cards for plotting are documented in the User's Manual. The PLØTEL elements are used for plotting the acoustic cavity shape. The plot request card "SET n INCLUDE PLØTEL" must be used where n is a set number.

1.9.3 Acoustic Cavity Example Problem

Table 1 contains a listing of the data cards used as a simple example of acoustic cavity analysis. The problem to be solved is illustrated in Figure 2. The model was subdivided into

only ten finite elements in order to limit the number of data cards. For reasonable engineering accuracy, this model should be subdivided into at least four times that number of elements.

Each data card in Table 1 is given a number on the left side. The format for each type of bulk data card is given in parentheses above the group of that type. The following is a brief description of each card:

Card(s)

1-5 Each data card in the Executive Control deck has the format of a request word and a selection separated by blanks or a comma. The ID card is first, the CEND card is last, but the intermediate cards may appear in any order. The user may put any pair of words on the ID card for identification purposes. In this particular case Rigid Format number 3 (SØL 3,0) was chosen which is Normal Modes analysis. A limit of 2 minutes CPU time was set (TIME 2).

6-7 The TITLE= and SUBTITLE= cards may contain any list of letters and numbers following the (=) sign. This list will appear on the first two lines of each output page.

8 The method of eigenvalue extraction is selected with the METHØD= data card. The number 11 refers to the identification number of an EIGR bulk data card which appears below as card 32 and 33.

9-11 A simple output request is illustrated with these cards. PRES=ALL will result in printout of all pressures at the GRIDF and GRIDS points. STRESS=ALL will result in the printout of all velocities in the elements. This printout will occur for all extracted eigenvectors. Selected points or elements can be printed via the SET card described in the User's Manual.

12 The BEGIN BULK card denotes the beginning of the bulk data deck. The Bulk Data Deck cards may occur in any order. Putting these cards in alphabetic sort will save NASTRAN sorting time in large problems, however.

13 In this problem all the parameters except slot width w_d are constant throughout the volume. The data values on the AXSLØT card will be used whenever a corresponding entry in the following cards is blank.

14-20 The location of points on the slot are defined with these cards. Cards 14, 16, 18 and 20 serve a dual purpose by defining a GRIDS point identification number in field 2 and a GRIDF point identification number in field 6. The two types of points thereby are forced to have the same locations at the interface.

21,22 The location of points within the axisymmetric fluid cavity are described by the GRIDF card. No points are allowed to have a zero or negative radius.

23-31 These cards describe the elements shown in Figure 2. Each element is given a unique identification number and a list of the connected GRIDS or GRIDF points. Since the parameters ρ and B are constants, these fields are left blank so the values on the AXSLØT card will be used.

32,33 The EIGR card is used to define parameters for eigenvalue extraction (resonant frequencies). More than one of these cards may appear. The method to be used is selected with the METHØD= data card in the Case Control Deck (card 8). With this particular card we selected the Givens Tridiagonalization method (GIV) with a desired number of three (Nd = 3) output mode shapes. The modes will be normalized such that the maximum pressure is 1.0 (NØRM=MAX). These two cards illustrate a continuation card.

34 The SLBDY card defines the boundary between the slot and the central cavity. Both the density (ρ) and the number of radial slots (M) are blank so the AXSLØT defaults are used, i.e. $\rho = 1.2\text{x}10^{-7}$ and M = 4. Only four GRIDS points are on the boundary so a continuation card is not necessary. Field 8 being blank signifies the last entry.

35. The ENDDATA card is required to denote the end of the bulk data. Any following cards will be ignored by NASTRAN.

Table 1. Example problem data cards.

Card No.		
1	ID ACØUS, MSC	
2	APP DISP	
3	SØL 3,0	Executive Control Cards
4	TIME 2	
5	CEND	
6	TITLE = ACØUSTIC CAVITY EXAMPLE PRØBLEM	
7	SUBTITLE = FIRST HARMØNIC	
8	METHØD = 11	
9	ØUTPUT	Case Control Data Cards
10	PRES = ALL	
11	STRESS = ALL	
12	BEGIN BULK	

Card No.	1	2	3	4	5	6	7	8	9	10
	(AXSLØT	ρ_d	B_d	N	w_d	M_d)				
13	AXSLØT	1.2-7	21.0	1		4				
	(GRIDS	Id	r	z	w	Id_f)				
14	GRIDS	2	4.0	0.0	0.2E 01	1				
15	GRIDS	3	8.0	.0	1.0					
16	GRIDS	5	4.0	4.0	2.0	4				
17	GRIDS	6	8.0	4.0	1.0					
18	GRIDS	8	4.0	8.0	2.0	7				
19	GRIDS	9	8.0	8.0	1.0					
20	GRIDS	12	4.0	1.2+1	2.0	11				
	(GRIDF	Id	r	z)						
21	GRIDF	10	2.0	12.0						
22	GRIDF	13	2.0	1.4E1						
	(CSLØT4	Id	P_1	P_2	P_3	P_4	ρ	B	M)	
23	CSLØT4	1	2	3	6	5				
24	CSLØT4	2	5	6	9	8 .				
	(CSLØT3	Id	P_1	P_2	P_3		ρ	B	M)	
25	CSLØT3	3	8	9	12					
	(CAXIF2	ID	P_1	P_2			ρ	B)		
26	CAXIF2	4	1	4						
27	CAXIF2	5	4	7						
28	CAXIF2	6	7	10						
29	CAXIF2	9	10	13						

(Continued)

Card No.	1	2	3	4	5	6	7	8	9	10
	(CAXIF3	Id	P_1	P_2	P_3		ρ	B)		
30	CAXIF3	7	7	10	11					
31	CAXIF3	8	10	11	13					
	(EIGR	Id	Method	f_1	f_2	Ne	Nd	Nz		+XYZ
	(+XYZ	NØRM)								
32	EIGR	11	GIV				3			+AB
33	+AB	MAX								
	(SLBDY	ρ	M	ID1	ID2	ID3	ID4	etc.)		
34	SLBDY			12	8	5	2			
35	ENDDATA									

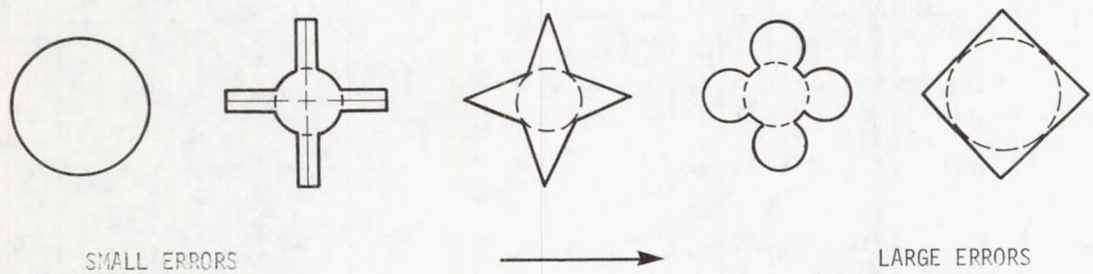
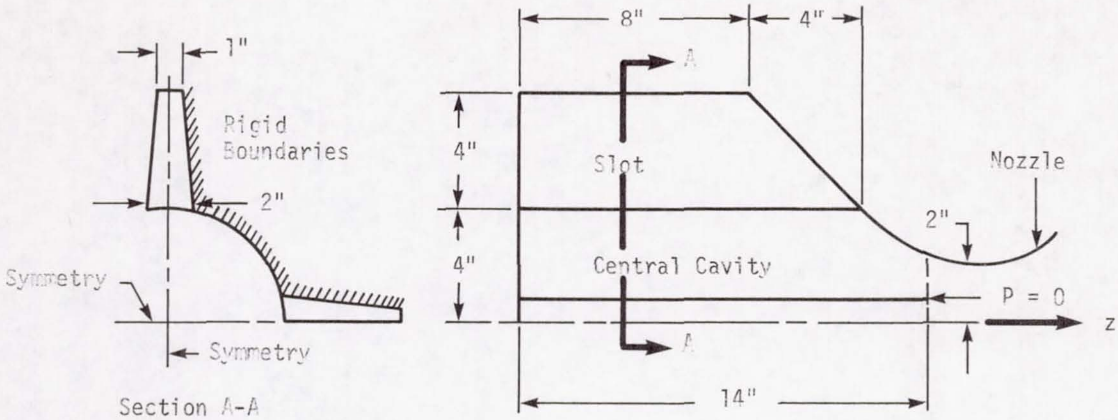


Figure 1. Modeling errors for various shapes.



Parameters:

Density: $\rho = 1.1463 \times 10^{-7}$ lb-sec^2/in^4

Bulk Modulus: $B = \rho a^2 = \gamma RT = 20.59$ lb/in^2

Harmonic: N = 1

Number of slots: M = 4

Note: Consistent Dimensional Units must be used.

FINITE ELEMENT MODEL:

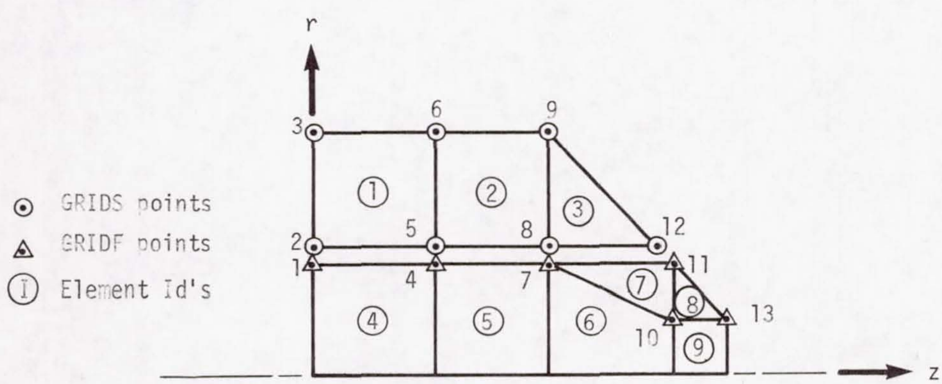


Figure 2. Description of example problem.

1.10 SUBSTRUCTURE ANALYSIS

The theoretical basis for NASTRAN substructuring is given in Section 4.3 of the Theoretical Manual. The NASTRAN substructuring technique may be used with any of the rigid formats, except Piecewise Linear Analysis. The following sections present instructions, including suggested DMAP alters, for use with the rigid formats for Static Analysis and Normal Modes Analysis.

Substructure analysis, as here defined, is a procedure in which the structural model is divided into separate parts which are then processed in separate computer executions to the point where the data blocks required to join each part to the whole are generated. The subsequent operations of merging the data for the substructures and of obtaining solutions for the combined problem are performed in one or more subsequent executions, after which detailed information for each substructure is obtained by additional separate executions.

Substructure analysis by the NASTRAN substructuring technique is logically performed in at least three phases as follows:

Phase I - Analysis of each individual substructure by NASTRAN to produce a description, in matrix terms, of its properties as seen at the boundary degrees of freedom, u_a.

Phase II - Combination of the matrix properties from Phase I and the inclusion, if desired, of additional terms to form a "pseudostructure," which is then analyzed by NASTRAN.

Phase III - Completion of the analysis of individual substructures using the $\{u_a\}$ vector produced in Phase II.

The NASTRAN Data Deck for each of the substructures is constructed in the same manner as for a NASTRAN analysis without substructuring. The following restrictions must be considered when forming the NASTRAN Data Deck for each of the substructures:

1. All points on boundaries between substructures which are to be joined must have their free degrees of freedom placed in the a-set.

2. The sequence of internal grid point identification numbers along the boundary between any two substructures must be the same. The internal sequence is the external sequence modified by any SEQGP cards. For example, if one substructure had boundary grid point internal identification numbers of 3, 4, 9, 27, and 31, the adjoining substructure could have a corresponding set of internal grid point identification numbers of 7, 11, 21, 22, and 41, but not 7, 11, 22, 21, and 41. This restriction is automatically satisfied if the same grid point numbers, without SEQGP cards, are used on the boundaries for connected substructures.

3. The displacement coordinate system for each group of connected grid points on the boundaries between substructures must be the same.

4. Elements located on the boundary may be placed in either adjacent substructure.

5. The loads applied to boundary points may be arbitrarily distributed between the adjoining substructures. Care should be exercised not to duplicate the loads by placing the entire load on each substructure.

6. The constrained stiffness matrix, $[K_{oo}]$, for each substructure must be nonsingular. This requirement is automatically satisfied in most cases, since usually there are enough degrees of freedom on the boundary of the substructure to account for its rigid body motions. In exceptional cases, such as when the substructure is a hinged appendage, it may be necessary for the user to assign additional degrees of freedom to u_a, rather than u_o.

Although the following discussion is limited to single-level substructuring, there is no inherent restriction on the use of multilevel substructuring in NASTRAN. In multilevel substructuring, some of the substructures are precombined in Phase II to form intermediate substructures. The final combination in Phase II then consists of joining two or more intermediate substructures. This procedure will be useful if there are several substructures in the model, and changes are made in only one or a few substructures. In this case, the amount of effort and computer time required for changes in the model can be substantially reduced if the unchanged substructures are initially combined into a single intermediate substructure.

1.10.1 Basic Substructure Analysis

Basic substructure analysis will be described with reference to the simple beam structure shown in Figure 1. The beam is arbitrarily separated into two substructures, referred to as substructure 1 and substructure 2, with a single boundary point being located at grid point 3. The beam is supported at grid points 1 and 6. No loads are applied to substructure 1. A single load is applied to substructure 2 at grid point 4, and a single load is applied at the boundary to grid point 3.

The complete NASTRAN Data Decks for all three phases of a substructure analysis for the beam shown in Figure 1 will be presented with comments for each card. The integers in the left-hand column will be used to relate the discussion to the cards in the NASTRAN Data Deck.

The following data deck is used for the Phase I of substructure 1:

```
ID        PHASE ØNE $ SUBSTRUCTURE 1
TIME      2
CHKPNT    YES
APP       DISP
SØL       1,1
ALTER     84
JUMP      LBL7 $
ALTER     102
FBS       LØØ,UØØ,PØ/UØØV $
CHKPNT    UØØV $
ØUTPUT1   E1,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP1 $
ALTER     103,126
ENDALTER
CEND
TITLE = PHASE ØNE - SUBSTRUCTURE 1
SPC = 101
BEGIN BULK
ASET      3       126
CBAR      1       10      1       2               1.0             1
CBAR      2       10      2       3               1.0             1
DMI       E1      0       2       1       1               3       1
DMI       E1      1       1       1.0     1.0     1.0
GRID      1                                               345
GRID      2               240.                            345
GRID      3               480.                            345
MAT1      11      30.+6
PBAR      10      11      60.     500.
SPC       101     1       12
ENDDATA
```

Comments are as follows:

101 ID card is first card of NASTRAN Data Deck.

102 TIME card is required in Executive Control Deck.

103 This run will be checkpointed, so that a restart can be made for Phase III. The user must arrange to have a physical tape mounted for the New Problem Tape (NPTP).

104 One of the rigid formats will be used for this problem.

105 Rigid Format 1, Static Analysis, will be used for this problem.

106 Insert the following statement after DMAP statement No. 84.

107 Jump around the Rigid Body Matrix Generator modules. The solution for $\{u_a\}$ will be performed in Phase II.

108 Insert the following three statements after DMAP statement No. 102.

109 Use the module FBS to solve for $\{u_o^o\}$ the displacement of the o-set points relative to the a-set points.

110 Write displacement vector UØØV on the New Problem Tape.

111 Use the module ØUTPUT1 to write the DMI matrix given on cards 121 and 122, along with the stiffness matrix KLL, and the load vector PL on User Tape 1 (USERTP1). The user must arrange to have a physical tape mounted for User Tape 1 (INPT). The details of the call for DMAP module ØUTPUT1 and other DMAP information are given in Section 5.

112 Delete the data recovery modules.

113 End of the ALTER package.

114 Last card of Executive Control Deck.

115 Title information for Phase I substructure 1 printed output.

116 Select single-point constraint set 101.

117 Indicates the beginning of the Bulk Data Deck.

118 Defines grid point 3 as a boundary point between substructures.

119, 120 Connection cards defining bar elements in substructure 1.

121, 122 Direct Matrix Input cards that define the partitioning vector for use in Phase II. The entries on these cards are discussed below.

123, 124, 125 These cards define the grid points in substructure 1.

126 Defines the material for the elements in substructure 1.

127 Defines the properties of the elements in substructure 1.

128 Defines single-point constraint set 101. Components 1 and 2 are constrained at grid point 1 in substructure 1.

129 End of NASTRAN Data Deck.

It should be noted that no output has been requested in the Case Control Deck for substructure 1. If the user wishes to have a plot of the undeformed structure for checking the model, a Plot Package can be inserted in the Case Control Deck in the usual way, as described in Section 4.2.

The partitioning matrix gives the relationship between the internal indices associated with the a-set matrices generated in Phase I and the external grid point component definition given on the grid cards that are input to Phase I as modified by any SEQGP cards. The same internal indices in Phase I for the a-set are redefined in Phase II as the indices for the g-set. The word pseudostructure is associated with the g-size matrices used in Phase II.

The partitioning matrix for the problem under consideration is given as follows:

PARTITIONING MATRIX

	External Grid-Component	
Internal Index	Substructure 1	Substructure 2
1	3-1	3-1
2	3-2	3-2
3	3-6	3-6

The procedure for constructing a partitioning matrix is as follows:

1. Select any one of the substructures and list the components of the a-set in sequence by grid point and component number as modified by any SEQGP cards (internal sequence). These are the nonzero entries in the partitioning vector for the first substructure.

2. Build the second column of the partitioning matrix by selecting any connected substructure and entering the connected components in the same row as the associated components in the first substructure.

3. Enter all unconnected a-set components in unoccupied rows of the partitioning matrix according to their internal sequence numbers. Unconnected members of the a-set having

internal sequence numbers in the range of the connected components will create new intermediate rows in the previously formed columns of the matrix.

4. Build the remaining columns of the partitioning matrix, one for each substructure, by following a similar procedure for all remaining substructures. In each case, first enter all components that are connected to the previously selected substructure or substructures, followed by the remaining unconnected components in their internal sequence.

5. The rows of the partitioning matrix are associated with the sequence of the internal indices for the scalar points in the pseudostructure. Any sequential set of integers may be used to identify these scalar points in Phase II.

6. The columns of the partitioning matrix (one vector for each substructure) are input with Direct Matrix Input (DMI) cards. The input matrix contains real 1's in all locations in the partitioning matrix having grid point-component entries. See Section 2.4 for DMI card format.

The DMI cards (121 and 122) in the sample problem give the name E1 to the partitioning vector for substructure 1. The first card defines the partitioning vector as being rectangular and consisting of real single-precision entries. The next to the last entry on the first card indicates there are three rows in the g-set matrices input to Phase II. The second integer 1 on the second card indicates that the first internal index is associated with one of the components in substructure 1; in this case, grid point 3, component 1. The three real 1.0's indicate the first three internal indices are associated with components in substructure 1; in this case, grid point 3, components 1, 2, and 6. In this particular case, only the initial two steps are required to construct the partitioning matrix and the partitioning vector for substructure 2 will be identical to that for substructure 1. This results from the fact that the single boundary point in this problem is a part of both substructures.

The partitioning vectors are not needed until Phase II. They were arbitrarily input to Phase I so they could be included on the User Tape, along with the output matrices from Phase I.

The NASTRAN Data Deck for substructure 2 is given below. For identification purposes, the cards are arbitrarily numbered beginning with 150.

```
ID          PHASE ØNE $ SUBSTRUCTURE 2
TIME        2
CHKPNT      YES
APP         DISP
SØL         1,1
ALTER       84
JUMP        LBL7 $
ALTER       102
FBS         LØØ,UØØ,PØ/UØØV $
CHKPNT      UØØV $
ØUTPUT1     E2,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP2 $
ALTER       103,126
ENDALTER
CEND
TITLE = PHASE ØNE - SUBSTRUCTURE 2
SPC = 201
LØAD = 202
BEGIN BULK
ASET        3       126
CBAR        3       10      3       4               1.0             1
CBAR        4       10      4       5               1.0             1
CBAR        5       10      5       6               1.0             1
DMI         E2      0       2       1       1               3       1
DMI         E2      1       1       1.0     1.0     1.0
FORCE       202     3               1000.           -1.0
FORCE       202     4               1000.           -1.0
GRID        3               480.                            345
GRID        4               720.                            345
GRID        5               960.                            345
GRID        6               1200.                           345
MAT1        11      30.+6
PBAR        10      11      60.     500.
```

182 SPC 201 6 2

183 ENDDATA

Comments are given only for those cards which are different from those given in substructure 1.

150 The ID card contains the comment following the dollar sign indicating the deck is for substructure 2.

160 The partitioning vector for substructure 2 is written on User Tape 2 and is named E2. The user must arrange to mount a second physical tape for INPT. It is possible to change the ØUTPUT1 statement and write the results for substructure 2 on the same tape as for substructure 1, if desired.

164 The printed output will indicate this run is for substructure 2.

165 Selects single-point constraint set 201.

166 Selects load set 202.

172, 173 Other than the name E2, the partitioning vector is identical to that for substructure 1.

174, 175 Defines the external loads in load set 202. The load applied to grid point 3 has arbitrarily been placed in substructure 2.

182 Defines single-point constraint set 201 at grid point 6, component 2.

The Phase II operations are concerned with merging the a-set matrices generated in Phase I which define the g-size pseudostructure in Phase II. The NASTRAN Data Deck for Phase II is given below. The cards are arbitrarily numbered beginning with 201.

```
201  ID        PHASE TWØ
202  TIME      2
203  APP       DISP
204  SØL       1,0
205  ALTER     1
206  PARAM     //C,N,NØP/V,N,TRUE=-1 $
207  ALTER     7,19
208  ALTER     22,50
209  INPUTT1   /E01,KGG01,PG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
210  MERGE,    ,,,KGG01,E01,/KGGT01 $
```

```
ADD        KGG,KGGT01/KT01 $
EQUIV      KT01,KGG/TRUE $
MERGE,     ,PG01,,,,E01/PGT01/C,N,1 $
ADD        PGT,PGT01/PT01 $
EQUIV      PT01,PGT/TRUE $
INPUTT1    /E02,KGG02,PG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,     ,,,KGG02,E02,/KGGT02 $
ADD        KGG,KGGT02/KT02 $
EQUIV      KT02,KGG/TRUE $
MERGE,     ,PG02,,,,E02/PGT02/C,N,1 $
ADD        PGT,PGT02/PT02 $
EQUIV      PT02,PGT/TRUE $
ALTER      60,64
ALTER      95,95
SSG1       SLT,BGPDT,CSTM,SIL,,MPT,,EDT,,CASECC,DIT/PG/V,N,LUSET/V,N,NSKIP $
ADD        PGT,PG/PGX $
EQUIV      PGX,PG/TRUE $
ALTER      119,120
ØUTPUT1,   ,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
PARTN      UGV,,E01/,ULV01,,/C,N,1 $
ØUTPUT1    ULV01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
PARTN      UGV,,E02/,ULV02,,/C,N,1 $
ØUTPUT1    ULV02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
SDR2       CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,PGG,QG,UGV,,/ØPG1,ØQG1,ØUGV1,,,/C,N,STATICS $
ØFP        ØUGV1,ØPG1,ØQG1,,,//V,N,CARDNØ $
ALTER      122,126
ALTER      130,131
ALTER      134,135
ENDALTER
CEND
TITLE = PHASE TWØ
BEGIN BULK
```

243	DMI	KGG	0	6	1	2		3	3
244	DMI	KGG	1	1	0.0				
245	DMI	PGT	0	2	1	2		3	1
246	DMI	PGT	1	1	0.0				
247	SPØINT	1	THRU	3					
248	ENDDATA								

Comments for each of the cards are as follows:

201 The ID card is the first card of the NASTRAN Data Deck.

202 The TIME card is required in the Executive Control Deck.

203 One of the rigid formats will be used to solve this problem.

204 Rigid Format 1, Static Analysis, will be used for this problem.

205 Insert the following statement after DMAP statement No. 1.

206 Define the parameter TRUE = -1.

207 Delete the DMAP statements associated with the preparation of the Element Connection Table and structure plots.

208 Delete the DMAP statements associated with matrix assembly.

209 Insert the DMAP module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 1. These matrices have been renamed E01, KGG01, and PG01, respectively. The user must arrange to have the tape mounted that was prepared during the Phase I run of substructure 1. This tape should be designated as INP1.

210 Insert the module MERGE to change the a-set size of the stiffness matrix from Phase I to g-size for Phase II, and designate the output as KGGT01. In this particular case, no change will take place, since the a-size from Phase I is the same as the g-size in Phase II.

211 Insert the module ADD to add the null matrix KGG, defined in the Bulk Data Deck, to KGGT01, and designate the output as KT01.

212 Insert the module EQUIV to equivalence KT01 to KGG.

213 Insert the module MERGE to change the a-size of the load vector from Phase I to g size for Phase II, and designate the output as PGT01. In this case, no change in size will take place.

214 Insert the module ADD to add the null matrix PGT, defined in the Bulk Data Deck, to PGT01, and designate the output as PT01.

215 Insert the module EQUIV to equivalence PT01 to PGT.

216 Insert the module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 2. These matrices which were generated for substructure 2 in Phase I are redesignated as E02, KGG02, and PG02, respectively.

217 Insert the module MERGE to change the stiffness matrix for substructure 2 from a-size in Phase I to g-size in Phase II and designate the output as KGGT02.

218 Insert the module ADD to add the stiffness matrix for substructure 2 to the stiffness matrix for substructure 1, and designate the output as KT02.

219 Insert module EQUIV to equivalence KT02 to KGG. The matrix KGG now represents the stiffness matrix for the pseudostructure, and will be used for input to Phase II.

220 Insert the module MERGE to change the load vector from a-size in Phase I to g-size in Phase II.

221 Insert the module ADD to add the loads applied to substructure 2 to the load vector for substructure 1, and designate the output as PT02.

222 Insert the module EQUIV to equivalence PT02 to PGT.

223 Delete the DMAP statements associated with the Grid Point Singularity Processor.

224 Delete the module SSG1 as given in Rigid Format 1.

225 Insert the module SSG1 with the calling sequence modified to remove parts not associated with directly applied loads. Since, for this particular problem, all loads were applied in Phase I, there will be no output from SSG1.

226 Insert the module ADD to combine the load vector from Phase II with the load vectors generated in Phase I, and designate the output as PGX.

227 Insert the module EQUIV to equivalence PGX to PG. The data block PG now includes all loads from both Phase I and Phase II, and will be used as input to Phase III.

228 Remove SDR2 and ØFP as given in Rigid Format 1.

229 Insert the module ØUTPUT1 to rewind User Tape 3 and place the label USERTP3 on this tape. The user must arrange to have a physical tape mounted and designated as INPT.

230 Insert the module PARTN to separate that part of the solution vector UGV associated with substructure 1, and designate the output as ULV01.

231 Insert the module ØUTPUT1 to write the partition of the solution vector associated with substructure 1 on User Tape 3.

232 Insert the module PARTN to separate that part of the solution vector associated with substructure 2, and designate the output as ULV02.

233 Insert the module ØUTPUT1 to write that part of the solution vector associated with substructure 2 on User Tape 3. This will place the solution vectors for both substructures on User Tape 3. A second tape could be used for the solution vector for substructure 2 by changing the DMAP statement for ØUTPUT1.

234 Insert the module SDR2 with the calling sequence modified to remove those parts associated with element output.

235 Insert the module ØFP with the calling sequence modified to remove those parts associated with element output.

236 Remove the DMAP statements associated with the preparation of the deformed structure plots.

237 Remove the statements associated with ERRØR2.

238 Remove the statements associated with ERRØR4.

239 End of ALTER package.

240 End of Executive Control Deck.

241 Title information for Phase II printed output.

242 Beginning of the Bulk Data Deck.

243, 244 DMI cards used to define the null matrix KGG.

245, 246 DMI cards used to define the null matrix PGT.

247 Definition of the three scalar points for the pseudostructure.

248 End of NASTRAN Data Deck.

Although the data deck shown above is prepared for two substructures, it was constructed in such a manner that it could be easily extended to more than two substructures. If there are more than two substructures, cards similar to 216 to 222, 232, and 233 need to be added to the NASTRAN data deck for each additional substructure.

The final part of a substructure analysis is to perform data recovery for each substructure of interest. These runs are made as a restart of the Phase I runs. Any of the normal rigid format output can be requested, including both undeformed and deformed structure plots. All of the output will be in terms of the elements and grid points defined in the Phase I Bulk Data Decks. The NASTRAN Data Deck for the Phase III analysis of substructure 1 is given as follows:

301 ID PHASE THREE $ SUBSTRUCTURE 1

```
302 TIME      2
303 APP       DISP
304 SØL       1,1
305 ALTER     20,109
306 INPUTT1   /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
307 INPUTT1   /ULV,,,,/C,N,0 $
308 ALTER     112,117
309 ALTER     127,138
310 ENDALTER
311    (Include Restart Dictionary from Phase I)
312 CEND
313 TITLE = PHASE THREE - SUBSTRUCTURE 1
314 DISP = ALL
315 ELFØRCE = ALL
316 ØLØAD = ALL
317 SPCFØRCE = ALL
318 BEGIN BULK
319    (No Bulk Data)
320 ENDDATA
```

Comments for each of the cards are as follows:

301 ID card is first card of the NASTRAN Data Deck.

302 TIME card is required in the Executive Control Deck.

303 One of the rigid formats will be used for this problem.

304 Rigid Format 1, Static Analysis, will be used for this problem.

305 Delete all parts of the rigid format, except the data recovery modules.

306 Insert module INPUTT1 to rewind and check the label on User Tape 3. The user must arrange to have User Tape 3 mounted and designated as INPT.

307 Insert module INPUTT1 to read the solution vector for substructure 1 from User Tape 3. The solution vector is designated as ULV for input to module SDR1.

308, 309 Remove additional DMAP statements not associated with data recovery operations.

310 End of ALTER package.

311 Insert the Restart Dictionary punched during the Phase I run of substructure 1.

312 End of Executive Control Deck.

313 Title information for printed output for Phase III.

314 Request printed output for all displacements of substructure 1.

315 Request printed output of forces for all elements in substructure 1.

316 Request printed output of the load vector for substructure 1. In this particular case, no output will result because no loads were applied to substructure 1.

317 Request printed output for all nonzero single-point forces of constraint on substructure 1.

318 Beginning of Bulk Data Deck.

319 No bulk data cards should be included in the Phase III run. However, the BEGIN BULK and ENDDATA cards must be present.

320 End of NASTRAN Data Deck.

The NASTRAN data deck for the Phase III analysis of substructure 2 is given below. Comments are restricted to cards that are different from those presented for the Phase III run of substructure 1.

```
350 ID         PHASE THREE $ SUBSTRUCTURE 2
351 TIME       2
352 APP        DISP
353 SØL        1,1
354 ALTER      20,109
355 INPUTT1    /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
356 INPUTT1    /ULV,,,,/C,N,1 $
357 ALTER      112,117
358 ALTER      127,138
359 ENDALTER
360    (Include Restart Dictionary from Phase I)
361 CEND
362 TITLE = PHASE THREE - SUBSTRUCTURE 2
363 DISP = ALL
364 ELFØRCE = ALL
```

365 ØLØAD = ALL

366 SPCFØRCE = ALL

367 BEGIN BULK

368 (No Bulk Data)

369 ENDDATA

Comments are as follows:

350 The comment following the dollar sign indicates this analysis is for substructure 2.

355 Insert module INPUTT1 to rewind User Tape 3. The user must arrange to mount User Tape 3, if it is not already mounted as a result of the previous run on substructure 1.

356 Insert module INPUTT1 to skip over the solution vector for substructure 1 on User Tape 3, and read the solution vector for substructure 2.

365 The request for printed output of the load vectors will show nonzero loads applied to grid points 3 and 4.

1.10.2 Loads and Boundary Conditions

The single load and the single boundary condition for the sample problem in Section 1.10.1 were introduced in Phase I. It is also possible to introduce loads and boundary conditions in Phase II. In this case, the loaded and/or constrained degrees of freedom must be included in the a-set for Phase I, so they will be a part of the pseudostructure in Phase II. Loads are applied to the pseudostructure in Phase II with the SLØAD card. This limits the type of load that can be applied in Phase II to directly applied loads. Other loading conditions depending on element properties or connection data, such as thermal loads, gravity loads, and pressure loads, must be applied in Phase I. Loads may be introduced in both Phases I and II, as the suggested DMAP sequence will add contributions to the load vector from both phases. The lack of generality for the application of loads in Phase II will often dictate that static loads be applied in Phase I.

The loads and boundary conditions for the sample problem can be applied in Phase II if the following modifications are made to the NASTRAN Data Decks presented in Section 1.10.1.

1. Remove card 116, SPC set selection for Phase I substructure 1.
2. Replace card 118 as shown below to redefine the a-set for substructure 1.

3. Replace cards 121 and 122 with cards 121, 122, and 122a shown below to redefine the partitioning vectors for substructure 1.

4. Card 128 is not required, SPC set definition for substructure 1.

5. Remove cards 165 and 166, SPC and load set selection for Phase I, substructure 2.

6. Replace card 168 as shown below to redefine the a-set for substructure 2.

7. Replace cards 172 and 173 with cards 172, 173, and 173a shown below to redefine the partitioning vectors for substructure 2.

8. Cards 174, 175, and 182 are not required, load definition and SPC definition for substructure 2.

9. Insert cards 241a and 241b as shown below after card 241 in the Case Control Deck for Phase II for the selection of the boundary conditions and loading condition.

10. Replace cards 243 and 245 as shown below to conform to new size for pseudostructure.

11. Insert the cards 246a and 246b as shown below in the Bulk Data Deck for Phase II for definition of the loading condition and boundary condition.

12. Replace card 247 as shown below to modify the definition of the pseudostructure to contain 12 scalar points.

118	ASET1	126	1	3						
121	DMI	E1	0	2	1	1		12	1	
122	DMI	E1	1	1	1.0	1.0	1.0	1.0	1.0	+E11
122a	+E11	E1	1.0							
168	ASET1	126	3	4	6					
172	DMI	E2	0	2	1	1		12	1	
173	DMI	E2	1	4	1.0	1.0	1.0	1.0	1.0	+E21
173a	+E21	E2	1.0	1.0	1.0	1.0				
241a	SPC = 201									
241b	LØAD = 202									
243	DMI	KGG	0	6	1	2		12	12	
245	DMI	PGT	0	2	1	2		12	1	
246a	SLØAD	202	5	1000.	8	1000.				
246b	SPC1	201		1	2	11				
247	SPØINT	1	THRU	12						

The modified partitioning matrix with grid points 1, 3, 4, and 6 in the a-set is shown below.

PARTITIONING MATRIX

Internal Index	External Grid-Component Substructure 1	External Grid-Component Substructure 2
1	1-1	
2	1-2	
3	1-6	
4	3-1	3-1
5	3-2	3-2
6	3-6	3-6
7		4-1
8		4-2
9		4-6
10		6-1
11		6-2
12		6-6

The modified partitioning matrix contains twelve scalar points, with six in substructure 1, nine in substructure 2, and three common to both substructures. The loads are now located at scalar points 5 and 8, as indicated on card 246a. The single-point constraints are located at scalar points 1, 2, and 11, as indicated on card 246b. The modified partitioning vector for substructure 1 indicates there are twelve degrees of freedom in the pseudostructure, and that, beginning with the first scalar point, there are six scalar points associated with substructure 1. The modified partitioning vector for substructure 2 indicates the first entry is associated with scalar point 4, and that there are a total of nine scalar points associated with substructure 2.

If multiple loading conditions are used in the solution, the subcase structure must be established in Phase I. In order to perform the matrix operations in Phase II, the same case control structure must be used for all substructures. This means that the same number of subcases must be defined for each substructure, even though some of the subcases will not contain a load selection or any other entries. NASTRAN will generate a null column in the load matrix for all subcases for which no load set is selected. If any loads are applied in Phase II, the same subcase structure must be used in Phase II. In any event, the subcase structure established in Phase I must be used in Phase III. The contents of each subcase in Phase III will relate to

output selections, rather than load and boundary condition selections.

Consider adding two additional loading conditions to the sample problem in Section 1.10.1. If one additional loading condition were applied to substructure 1, identified as 202, and one additional loading to substructure 2, identified as 203, the subcase structure established in Phase I would appear as follows:

Substructure 1	Substructure 2
SPC = 101	SPC = 201
SUBCASE 1	SUBCASE 1
	LØAD = 201
SUBCASE 2	SUBCASE 2
LØAD = 202	
SUBCASE 3	SUBCASE 3
	LØAD = 203

Load case 202 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 1. In addition, load set 203 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 2.

The suggested DMAP sequence for the sample problem in Section 1.10.1 will not support multiple boundary conditions in Phase I. If multiple boundary conditions are introduced in Phase I, it is necessary to generate a separate partitioning vector for use in Phase II for each of the unique boundary conditions. In some sense, this results in the definition of a number of separate problems equal to the number of unique boundary conditions. Although a DMAP sequence could be developed to support multiple boundary conditions in Phase I, it is not recommended that multiple boundary conditions be introduced into Phase I.

Multiple boundary conditions may be introduced in Phase II without any difficulty. However, in order to handle the internal looping for each boundary condition, it is more convenient if the loads are also introduced in Phase II. As indicated earlier, the introduction of loads in Phase II does limit the manner in which the static loads can be defined. If the loads and boundary conditions are introduced in Phase II, all of the case control options for combining subcases, including symmetry combinations, may be used in the usual manner.

It is possible to introduce the loads in Phase I and multiple boundary conditions in Phase II. However, provision must be made to generate all loading conditions in Phase I, which will automatically take place if one subcase is defined for each loading condition and no boundary conditions are mentioned in the Phase I Case Control Deck. It is then necessary in Phase II to partition out the proper columns of the loading matrix for each loop or boundary condition in Phase II. This requires that the user construct the proper partitioning vector for each boundary condition. Also, appropriate modifications would have to be made to the suggested DMAP sequence for Phase II.

1.10.3 Dynamic Analysis

Substructuring for dynamic analysis is performed in much the same way as that for static analysis. A suggested NASTRAN Data Deck for use in Phase I of a Normal Modes Analysis (Rigid Format 3) is shown below:

```
ID        PHASE ØNE $ NØRMAL MØDES
TIME      2
CHKPNT    YES
APP       DISP
SØL       3,0
ALTER     75,112
ØUTPUT1   E10,KAA,MAA,,//C,N,-1/C,N,0/C,N,USERTP1 $
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

Note that the ØUTPUT1 module writes the mass matrix, as well as the stiffness matrix and partitioning vector on User Tape 1. The Case Control Deck is similar to the Phase I deck for static analysis. It must include a constraint selection if the boundary conditions are applied in Phase I. The Bulk Data Deck is also similar to that used in Phase I for static analysis. In general, it includes all the cards associated with the definition of the model and the DMI cards for the definition of the partitioning vector. It will also include cards for the definition of

the a-set and other constraint cards if the boundary conditions are applied in Phase I. As in static analysis, one such deck must be prepared for each substructure.

The suggested NASTRAN Data Deck for Phase II of Normal Modes Analysis with two substructures is shown below:

```
ID        PHASE TWØ $ NØRMAL MØDES
TIME      2
APP       DISP
SØL       3,0
ALTER     1
PARAM     //C,N,NØP/V,N,TRUE=-1 $
ALTER     6,41
INPUTT1   /E01,KGG01,MGG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
MERGE,    ,,,KGG01,E01,/KGGT01 $
ADD       KGG,KGGT01/KT01 $
EQUIV     KT01,KGG/TRUE $
MERGE,    ,,,MGG01,E01,/MGGT01 $
ADD       MGG,MGGT01/MT01 $
EQUIV     MT01,MGG/TRUE $
INPUTT1   /E02,KGG02,MGG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,    ,,,KGG02,E02,/KGGT02 $
ADD       KGG,KGGT02/KT02 $
EQUIV     KT02,KGG/TRUE $
MERGE,    ,,,MGG02,E02,/MGGT02 $
ADD       MGG,MGGT02/MT02 $
EQUIV     MT02,MGG/TRUE $
ALTER     50,54
ALTER     105,106
ØUTPUT1   LAMA,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E01/,PHIA01,,/C,N,1 $
ØUTPUT1   PHIA01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E02/,PHIA02,,/C,N,1 $
```

```
ØUTPUT1   PHIA02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,,/,ØQG1,ØPHIG,,,/C,N,REIG $
ØFP       ØPHIG,ØQG1,,,,//V,N,CARDNØ $
ALTER     108,112
ALTER     114,115
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

The Phase II NASTRAN Data Deck for Normal Modes Analysis is similar to that used for Static Analysis. The following comments are related to differences in the two decks:

1. Since there are no loads associated with a normal modes analysis, the module GP3 is not executed.
2. The same operations are performed on the mass matrix as are performed for the stiffness matrix.
3. The data block LAMA (Eigenvalue Summary) is written as the first data block on User Tape 3. This is followed by the appropriate partitions of the eigenvectors for each of the substructures.
4. The Case Control Deck must include a method selection for eigenvalue extraction.
5. The Bulk Data Deck is similar to that used in static analysis, except that a null matrix must be defined for the mass matrix, instead of the load matrix, and an EIGR card must be included.

In dynamic analysis, the a-set will include, in addition to all points on the boundary of the substructure, a number of points within each substructure sufficient to define the dynamic response. Since all active degrees of freedom along interior boundaries must be included in u_a, the a-set will contain more degrees of freedom than are needed in dynamic analysis, with a large resulting inefficiency for a very small gain in accuracy. This is a serious consideration because, due to the high density of K_{aa}, the time to perform most of the significant matrix operations in Phase II increases nearly as the cube of the number of degrees of freedom in u_a. The situation can be greatly improved by a second stiffness reduction in Phase II, in which u_a is partitioned into a set, u_c, that will be retained in dynamic analysis, and a set, u_b, that will be eliminated. The u_b set includes the excess degrees of freedom on the interior boundaries.

The second stiffness reduction in Phase II is defined by listing the members of the u_b set that will be eliminated on ØMIT cards. These omitted degrees of freedom must reference the scalar points associated with the pseudostructure.

In Phase III for dynamics, each NASTRAN substructure is restarted with the partition of the Phase II solution vector, or eigenvector, for each substructure. All normal data reduction procedures may then be applied. In dynamic analysis, Phase III can be omitted if output requests are restricted to the response quantities for the scalar points of the pseudostructure. In this case, the output and partition modules can be omitted from the Phase II runs, as their only purpose is to serve as input for the Phase III runs.

If output is desired for dependent response quantities or element stresses and forces, a Phase III run must be made for each substructure of interest. The suggested NASTRAN Data Deck is given below for a Phase III dynamics run:

```
ID          PHASE THREE $ NØRMAL MØDES
TIME        2
APP         DISP
SØL         3,0
ALTER       19,94
INPUTT1     /LAMA,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
INPUTT1     /PHIA,,,,/C,N,0 $
ALTER       113,120
ENDALTER
   (Include Restart Dictionary from Phase I)
CEND
   (Case Control Deck)
BEGIN BULK
   (No Bulk Data)
ENDDATA
```

The Phase III data deck for Normal Modes Analysis is similar to that used for Static Analysis. The first reference to module INPUTT1 is to read the data block LAMA, which is the first data block on User Tape 3. The second reference to INPUTT1 is to read the proper partition of the eigenvectors. The zero parameter at the end of the statement should be

incremented one for each substructure in order to point to the proper eigenvector partition.

Substructuring may be used with any of the other dynamics rigid formats. The NASTRAN Data Decks will be similar to those used for Normal Modes Analysis. All dynamic loads must be applied in Phase II. If the SUPØRT card is needed to define free body motions for the structure as a whole, it must be included in Phase II.

1.10.4 DMAP Loops for Phase II

The suggested DMAP sequences for the substructure example in Section 1.10.1 uses repeated blocks of code for each substructure. Cards 209 through 215 are associated with input for substructure 1. Cards 216 through 222 perform the same operations for substructure 2. Likewise, cards 230 and 231 are associated with output for substructure 1, and cards 232 and 233 are associated with output for substructure 2. If a large number of substructures are used, it is more convenient to use a DMAP loop, rather than repeating blocks of code. DMAP loops are constructed by placing a LABEL statement at the beginning of the loop and an REPT statement at the end of the loop. The number of times the REPT statement must be executed is set by an integer constant.

The series of statements represented by cards 209 through 222 can be replaced with the following sequence of DMAP operations:

```
PARAM      // C,N,NØP / V,N,INP=1 $
LABEL      BLØCK1 $
INPUTT1    / E,KGGA,PGA,, / C,N,-3 / V,N,INP $
MERGE,     ,,,KGGA,E, / KGGTA $
ADD        KGG,KGGTA / KTA $
EQUIV      KTA,KGG / TRUE $
MERGE,     ,PGA,,,,E / PGTA / C,N,1 $
ADD        PGT,PGTA / PTA $
EQUIV      PTA,PGT / TRUE $
PARAM      // C,N,ADD / V,N,INP / V,N,INP / C,N,1 $
REPT       BLØCK1,1 $
```

The LABEL, BLØCK1, is shown at the beginning of the loop, and the REPT statement is shown at the end. The integer in the REPT statement is set to one less than the number of substructures,

which in this case is one. The PARAM statement preceding the REPT statement is used to increment the second parameter of INPUTT1 by one each time through the loop. This causes the information to be read from a different tape each time through the loop. This DMAP loop does not check the label before reading the information on the input tape. The fact that the same names are used for the matrices each time through the loop does not cause any difficulty, as the matrices are located by their position on the tape, rather than by name.

If a DMAP loop is used for the input sequence, consideration must be given to its effect on the output sequence. Since the partitioning vectors were not saved on each pass through the DMAP loop for the input sequence, it is necessary to recover this information for use in the output sequence. This might be done by rerunning INPUTT1 to reread the partitioning vectors as needed, or perhaps by inserting the DMI cards for the partitioning vectors in the Bulk Data Deck for Phase II. If Phase III runs are not required, no output sequence is necessary.

1.10.5 Identical Substructures

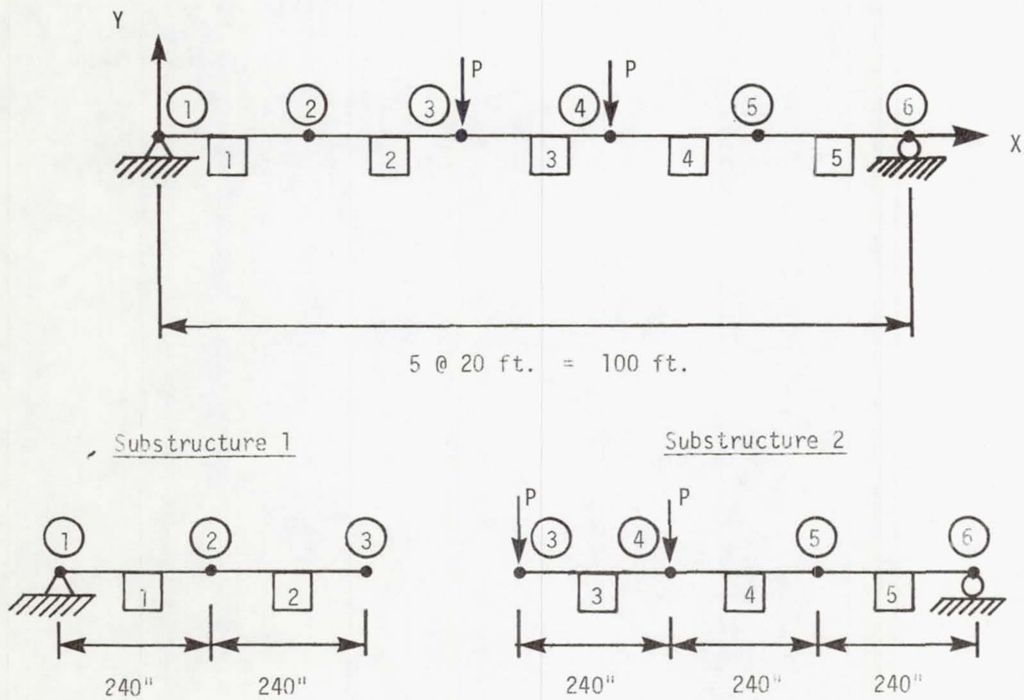
In the case of identical substructures, the substructuring procedures can be organized to take full advantage of the repetitive parts. The substructures only have to appear identical in Phase I. The loading conditions and boundary conditions used in Phase II may be quite different for the otherwise identical substructures. The Phase I substructures must have identical geometry, including the global coordinate systems used on the boundary grid points.

Only a single Phase I run is made for each group of identical substructures. Since the identical substructures will be coupled in different ways during Phase II, a different partitioning vector must be generated for each use of the identical substructures in Phase II. These multiple partitioning vectors can be placed on the same output tape from Phase I, which also contains the single set of structural and loading matrices for the group of identical substructures.

The user may choose to make one or more Phase III runs for the members of a group of identical substructures. If the loading conditions and boundary conditions are also identical for the group of identical substructures, a single Phase III run will give all information of interest. However, if the boundary conditions and/or loading conditions are different for the various members of the group of identical substructures, it will probably be desirable to make a separate Phase III run for each of the substructures used in the complete structural model.

SUBSTRUCTURE ANALYSIS

The use of identical substructures not only saves time in computer runs for Phase I and perhaps for Phase III, but also substantially reduces the effort associated with the preparation of the structural model in the Bulk Data Deck. In some sense, substructuring procedures with identical substructures can be thought of as being a form of data generation. Although substructuring is usually used because of problem size, it may be desirable, in some cases, to use substructuring because of the repetitive nature of the structure, and a consequent saving in data generation effort.



(2) Grid Point Numbers

[3] Element Numbers

$E = 30 \times 10^6$ psi

$I = 500\ in^4$

$P = 1000$ lbs

FIGURE 1. Substructure Problem

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck, which consists of the following three sections:

1. Executive Control Deck
2. Case Control Deck
3. Bulk Data Deck

In some cases, the NASTRAN card may precede the Executive Control Deck. The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

$$\text{NASTRAN keyword}_1 = \text{value, keyword}_2 = \text{value, . . .}$$

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different than the default value. In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.

2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

MACHINE	CØNFIG	MØDEL NØ.
IBM 360/370	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195
	9	155
	10	165
CDC 6000	0 (default)	6600
	6	6400

The machine type is automatically determined by NASTRAN. If the model number is the default, the CONFIG keyword is not needed on the NASTRAN card. It is important to

indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect. Additional information for the NASTRAN card is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card, as indicated in Figure 1. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

The Case Control Deck begins with the first card following CEND and ends with the card preceeding BEGIN BULK, as indicated in Figure 1. It defines the subcase structure for the problem, makes selections from the Bulk Data Deck, and makes output requests for printing, punching and plotting. A general discussion of the functions of the Case Control Deck and a detail description of the cards used in this deck are given in Section 2.3. The special requirements of the Case Control Deck for each rigid format are discussed in Section 3.

The Bulk Data Deck begins with the card following BEGIN BULK and ends with the card preceeding ENDDATA, as indicated in Figure 1. It contains all of the details of the structural model and the conditions for the solution. The BEGIN BULK and ENDDATA cards must be present even though no new bulk data is being introduced into the problem or all of the bulk data is coming from an alternate source, such as User's Master File or user generated input. The format of the BEGIN BULK card is free field. The ENDDATA card must begin in column 1 or 2. Generally speaking only one structural model can be defined in the Bulk Data Deck. However, some of the bulk data, such as cards associated with loading conditions, constraints, direct input matrices, transfer functions and thermal fields may exist in multiple sets. All types of data that are available in multiple sets are discussed in Section 2.3.1. Only sets selected in the Case Control Deck will be used in any particular solution.

Comment cards may be inserted in any of the parts of the NASTRAN Data Deck. These cards are identified by a $ in column one. Columns 2-72 may contain any desired text.

GENERAL DESCRIPTION OF DATA DECK

Except for the IBM 360/370 series, all NASTRAN data cards must be punched using the character set shown in the table below. The EBCDIC character set may be used on the IBM 360/370 series. Any EBCDIC characters are automatically translated into the character set shown in the table below. The EBCDIC character card punch configurations are shown in parenthesis for the five characters that differ from the standard character set.

Character	Card Punch(s)	Character	Card Punch(s)	EBCDIC Punch(s)
blank	blank	N	11-5	
0	0	Ø	11-6	
1	1	P	11-7	
2	2	Q	11-8	
3	3	R	11-9	
4	4	S	0-2	
5	5	T	0-3	
6	6	U	0-4	
7	7	V	0-5	
8	8	W	0-6	
9	9	X	0-7	
A	12-1	Y	0-8	
B	12-2	Z	0-9	
C	12-3	$	11-3-8	
D	12-4	/	0-1	
E	12-5	+	12	(12-6-8)*
F	12-6	-	11	
G	12-7	(	0-4-8	(12-5-8)*
H	12-8	)	12-4-8	(11-5-8)*
I	12-9	'	4-8	(5-8)*
J	11-1	=	3-8	(6-8)*
K	11-2	,	0-3-8	
L	11-3	.	12-3-8	
M	11-4	*	11-4-8	

*IBM 360,370 only.

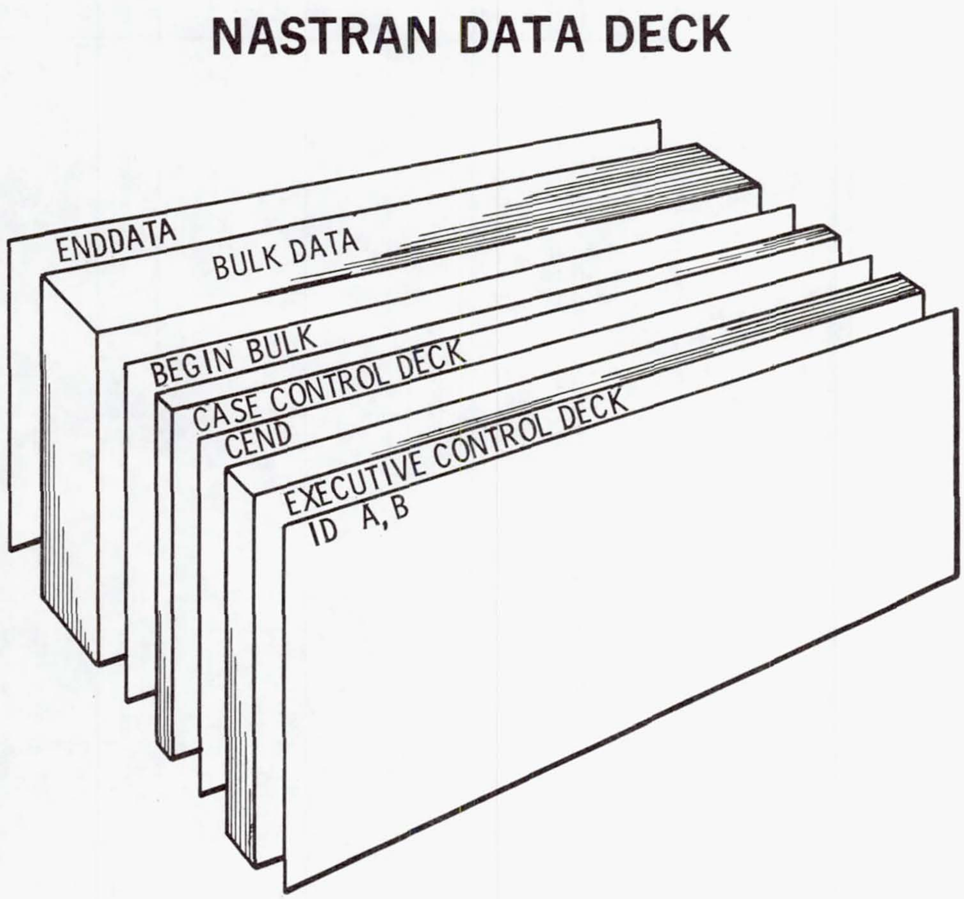


Figure 1. NASTRAN data deck.

2.2 EXECUTIVE CONTROL DECK

The format of the Executive control cards is free field. The name of the operation (e.g., CHKPNT) begins in column 1 and is separated from the operand by one or more blanks. The fields in the operand are separated by commas, and may be integers (Ki) or alphanumeric (Ai) as indicated in the following control card descriptions. The first character of an alphanumeric field must be alphabetic followed by up to 7 additional alphanumeric characters. Blank characters may be placed adjacent to separating commas if desired. The individual cards are described in Section 2.2.1 and examples follow in Section 2.2.2.

2.2.1 Executive Control Card Descriptions

ID A1, A2 Required.

A1, A2 -- Any legal alphanumeric fields chosen by the user for problem identification.

RESTART A1, A2, K1/K2/K3, Required for Restart.

A1, A2 -- Fields taken from ID card of previously checkpointed problem.

K1/K2/K3 -- Month/Day/Year that Problem Tape was generated.

The complete restart dictionary consists of this card followed by one card for each file checkpointed. The restart dictionary is automatically punched when operating in the checkpoint mode. All subsequent cards are continuations of this logical card.

Each continuation card begins with a sequence number. Each type of continuation card will be documented separately.

1. Basic continuation card

   NO,DATABLØCK,FLAG=Y,REEL=Z,FILE=W

   where: NO is the sequence number of the card. The entire dictionary must be in sequence by this number.

   DATABLØCK is the name of the data block referenced by this card.

   FLAG=Y defines the status of the data block where Y = 0 is the normal case and Y = 4 implies this data block is equivalenced to another data block. In this case (FLAG=4) the file number points to a previous data block which is the "actual" copy of the data.

REEL=Z specifies the reel number as the Problem Tape can be a multi-reel tape. Z = 1 is the normal case.

FILE=W specifies the GINØ (internal) file number of the data block on the Problem Tape. A zero value indicates the data block is purged. For example:

1,GPL,FLAGS=0,REEL=1,FILE=7 says data block GPL occupies file 7 of reel 1.

2,KGG,FLAGS=4,REEL=1,FILE=20 says KGG is equivalenced to the data block which occupies file 20. (Note that FLAGS=4 cards usually occur in at least pairs as the equivalenced operation is at least binary).

3,USETD,FLAGS=0,REEL=1,FILE=0 implies USETD is purged.

2. Reentry point card:

NO,REENTER AT DMAP SEQUENCE NUMBER N

where: NO is the sequence number of the card.

N is the sequence number associated with the DMAP instruction at which the problem will restart. This value may be changed by adding a final such card (i.e., only the last such card is operative). This may be necessary when restarting from a Rigid Format to a DMAP sequence (to print a matrix for example).

There are four types of restarts Unmodified Restart, Modified Restart, Rigid Format Switch and Pseudo Modified Restart. The function of the reentry point is different in each case. On an unmodified restart the program continues from the reentry point. On a modified restart modules which must be run to process the modified data but which are ahead of the reentry point are executed first. The program then continues from the reentry point. On a Rigid Format Switch (going from a Rigid Format to another) the reentry point is meaningless in that it was determined for another DMAP sequence. In this case the data blocks available are consulted to determine the proper sequence of modules to run. A Pseudo modified restart (defined by the existence of only changes to output producing data such as plotter requests) is treated like a modified restart. The type of restart is implied by the changes made in the NASTRAN Data Deck. No explicit request for a particular kind of restart is required. See Section 3.1 for additional information.

3. End of dictionary card

   $ END ØF CHECKPØINT DICTIØNARY

This card is simply a comment card but is punched to signal the end of the dictionary for user convenience. The program does not need such a card. Terminations associated with non-NASTRAN failures (operator intervention, maximum time etc.) will not have such a card punched.

UMF K1, K2 Required when using User's Master File.

K1 -- User specified tape identification number assigned during the generation of the User's Master File.

K2 -- Problem identification number assigned during generation of User's Master File.

CHKPNT A1 or CHKPNT A1, A2 Optional.

A1 -- YES if problem is to be checkpointed, NØ if problem is not to be checkpointed - default is NØ.

A2 -- DISK if checkpoint file is on direct access device. If the DISK option is used, the user must instruct the resident operating system to permanently catalog the checkpoint file.

APP A Required.

A -- DISPLACEMENT indicates one of the Displacement Approach rigid formats.

A -- HEAT indicates one of the Heat Transfer Approach rigid formats.

A -- DMAP indicates Direct Matrix Abstraction Approach (DMAP).

SØL K1 [,Ki] or SØL An [,Ki] Required when using a rigid format (see Section 3.1 for available options).

K1 -- Solution number of Rigid Format (see table below and Section 3.1).

Ki -- Subset numbers for solution K1, default value = 0. (see Section 3.1 for the allowable subsets.)

An -- Name of Rigid Format (see table below)

Displacement Approach Rigid Formats

K1	An
1	STATICS
2	INERTIA RELIEF
3	MØDES or NØRMAL MØDES or REAL EIGENVALUES
4	DIFFERENTIAL STIFFNESS
5	BUCKLING
6	PIECEWISE LINEAR
7	DIRECT CØMPLEX EIGENVALUES
8	DIRECT FREQUENCY RESPØNSE
9	DIRECT TRANSIENT RESPØNSE
10	MØDAL COMPLEX EIGENVALUES
11	MØDAL FREQUENCE RESPØNSE
12	MØDAL TRANSIENT RESPØNSE

Heat Transfer Approach Rigid Formats

K1	An
1	STATICS
3	STEADY STATE
9	TRANSIENT

ALTER K1, K2 Optional.

K1, K2 -- First and last DMAP instructions of series to be deleted and replaced with any following DMAP instructions.

ALTER K Optional.

K -- Input any following DMAP instructions after statement K.

TIME K Required.

K -- Maximum allowable execution time in minutes.

ENDALTER Required when using ALTER.

Indicates end of DMAP alterations.

DIAG K Optional request for diagnostic output.

K = 1	Dump memory when non-preface fatal message is generated.
K = 2	Print File Allocation Table (FIAT) following each call to the File Allocator.
K = 3	Print status of the Data Pool Dictionary (DPD) following each call to the Data Pool Housekeeper.
K = 4	Print the Operation Sequence Control Array (ØSCAR).
K = 5	Print BEGIN time on-line for each functional module.
K = 6	Print END time on-line for each functional module.
K = 7	Print eigenvalue extraction diagnostics for real and complex determinant methods.
K = 8	Print matrix trailers as the matrices are generated.
K = 9	Suppress echo of checkpoint dictionary.
K = 10	Use alternate nonlinear loading in TRD. (Replace $\{N_{n+1}\}$ by $\frac{1}{3}\{N_{n+1} + N_n + N_{n-1}\}$)
K = 11	Print all active row and column possibilities for decomposition algorithms.
K = 12	Print eigenvalue extraction diagnostics for complex inverse power.
K = 13	Print open core length.
K = 14	Print the Rigid Format (NASTRAN SØURCE PRØGRAM CØMPILATIØN) for all non-Restart runs.
K = 15	Trace GINØ ØPEN/CLØSE operations.
K = 16	Trace real inverse power eigenvalue extraction operations.
K = 17	Punch the DMAP sequence that is compiled.
K = 18	Trace Heat Transfer iterations.
K = 19	Print data for MPYAD method selection.
K = 20	Generate de-bug printout (For NASTRAN programmers who include CALL BUG in their subroutines).
K = 21	Print GP4 set definition.
K = 22	Print GP4 degree of freedom definition.
K = 23-26	Not used.
K = 27	Input File Processor (IFP) table dump.
K = 28	Punch the link specification table (Deck XBSBD).
K = 29	Process link specification table update deck.
K = 30	Punch alters to the XSEMi decks (i set via DIAG 1-15).
K = 31	Print link specification table and module properties list data.

Multiple options may be selected by using multiple integers separated by commas. Other options and other rules associated with the DIAG card which primarily concern the programmer can be found in Section 6.11.3 of the Programmer's Manual.

BEGIN$ Required when using DMAP approach.

Indicates beginning of DMAP sequence. This card is supplied as part of a Rigid Format.

END$ Required when using DMAP approach.

Indicates end of DMAP sequence. This card is supplied as part of a Rigid Format.

UMFEDIT Required when using User's Master File Editor (see Section 2.5)

CEND Required

Indicates end of Executive control cards.

The ID card must appear first and CEND must be the last card of the Executive Control Deck. Otherwise the Executive Control card groups (RESTART dictionary, DMAP sequence, ALTER packet) can be in any order.

2.2.2 Executive Control Deck Examples

1. Cold start, no checkpoint, rigid format, diagnostic output.

```
ID        MYNAME, BRIDGE23
APP       DISPLACEMENT
SØL       2,0
TIME      5
DIAG      1,2
CEND
```

2. Cold start, checkpoint, rigid format.

```
ID        PERSØNZZ, SPACECFT
CHKPNT    YES
APP       DISPLACEMENT
SØL       1,3
TIME      15
CEND
```

3. Restart, no checkpoint, rigid format. The restart dictionary indicated by the brace is automatically punched on previous run in which the CHKPNT option was selected by the user.

```
ID JØESHMØE, PRØJECTX
RESTART  PERSØNZZ, SPACECFT, 05/13/67,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0 REEL=1, FILE=7
                    .
                    .
                    .
$ END OF CHECKPØINT DICTIØNARY
APP         DISPLACEMENT
SØL         3,3
TIME        10
CEND
```

4. Cold start, no checkpoint, DMAP. User-written DMAP program is indicated by braces.

```
ID          IAM007, TRYIT
APP         DMAP
BEGIN $

{DMAP statements go here}

END $
TIME        8
CEND
```

5. Restart, checkpoint, altered rigid format, diagnostic output.

```
ID GØØDGUY, NEATDEAL
RESTART BADGUY, NØSHØW, 05/09/68,
    1, XVPS, FLAGS=0, REEL=1, FILE=6
    2, REENTER AT DMAP SEQUENCE NUMBER 7
    3, GPL, FLAGS=0, REEL=1, FILE=7
                 .
                 .
                 .
$ END ØF CHECKPØINT DICTIØNARY
CHKPNT       YES
DIAG         2,4
APP          DISPLACEMENT
SØL          3,3
TIME         15
ALTER        20
MATPRN       KGGX,,,,// $
TABPT        GPST,,,,// $
ENDALTER
CEND
```

2.3 CASE CONTROL DECK

2.3.1 Data Selection

The case control cards that are used for selecting items from the Bulk Data Deck are listed below in functional groups. A detailed description of each card is given in Section 2.3.4. The first four characters of the mnemonic are sufficient if unique.

The following case control cards are associated with the selection of applied loads for both static and dynamic analysis:

1. DEFØRM - selects element deformation set.
2. DLØAD - selects dynamic loading condition.
3. DSCØEFFICIENT - selects loading increments for static analysis with differential stiffness.
4. LØAD - selects static loading condition.
5. NØNLINEAR - selects nonlinear loading condition for transient response.
6. PLCØEFFICIENT - selects loading increments for piecewise linear analysis.

The following case control cards are used for the selection of constraints:

1. AXISYMMETRIC - selects boundary conditions for conical shell elements or specifies the existence of fluid harmonics for a hydroelastic problem.
2. MPC - selects set of multipoint constraints.
3. SPC - selects set of single-point constraints.

The following case control cards are used for the selection of direct input matrices:

1. B2PP - selects direct input damping matrices.
2. K2PP - selects direct input stiffness matrices.
3. M2PP - selects direct input mass matrices.
4. TFL - selects transfer functions.

The following case control cards specify the conditions for dynamic analyses:

1. CMETHØD - selects the conditions for complex eigenvalue extraction.
2. FREQUENCY - selects the frequencies to be used for frequency and random response calculations.
3. IC - selects the initial conditions for direct transient response.
4. METHØD - selects the conditions for real eigenvalue analysis.
5. RANDØM - selects the power spectral density functions to be used in random analysis.

6. SDAMPING - selects table to be used for determination of modal damping.

7. TSTEP - selects time steps to be used for integration in transient response problems.

The following case control cards are associated with the use of thermal fields:

1. TEMPERATURE(LØAD) - selects thermal field to be used for determining equivalent static loads.

2. TEMPERATURE(MATERIAL) - selects thermal field to be used for determining material properties.

3. TEMPERATURE - selects thermal field for determining both equivalent static loads and material properties.

2.3.2 Output Selection

Printer output requests may be grouped in packets following ØUTPUT cards or the individual requests may be placed anywhere in the Case Control Deck ahead of any structure plotter or curve plotter requests. Plotter requests are described in Section 4. The case control cards that are used for output selection are listed below in functional groups. A detailed description of each card is given in Section 2.3.4.

The following cards are associated with output control, titling and bulk data echoes:

1. TITLE - defines a text to be printed on first line of each page of output.

2. SUBTITLE - defines a text to be printed on second line of each page of output.

3. LABEL - defines a text to be printed on third line of each page of output.

4. LINE - sets the number of data lines per printed page, default is 50 for 11-inch paper.

5. MAXLINES - sets the maximum number of output lines, default is 20,000.

6. ECHØ - selects echo options for Bulk Data Deck, default is a sorted bulk data echo.

The following cards are used in connection with some of the specific output requests for calculated quantities:

1. SET - defines lists of point numbers, elements numbers, or frequencies for use in output requests.

2. ØFREQUENCY - selects a set of frequencies to be used for output requests in frequency response problems; default is all frequencies used in the calculations.

3. TSTEP - selects a set of time steps to be used for output requests in transient response problems.

The following cards are used to make output requests for the calculated response of components in the SØLUTIØN set (components in the direct or modal formulation of the general K system) for dynamics problems:

1. SACCELERATIØN - requests the acceleration of the independent components for a selected set of points or modal coordinates.

2. SDISPLACEMENT - requests the displacements of the independent components for a selected set of points or modal coordinates.

3. SVELØCITY - requests the velocities of the independent components for a selected set of points or modal coordinates.

4. NLLØAD - requests the nonlinear loads for a selected set of PHYSICAL points (grid points and extra points introduced for dynamic analysis) in transient response problems.

The following cards are used to make output requests for stresses and forces, as well as the calculated response of degrees of freedom used in the model:

1. ELFØRCE - requests the forces in a set of structural elements.

2. STRESS - requests the stresses in a set of structural elements.

3. SPCFØRCES - requests the single-point forces of constraint at a set of points.

4. ØLØAD - selects a set of applied loads for output.

5. ACCELERATIØN - requests the accelerations for a selected set of PHYSICAL points (grid, scalar and fluid points plus extra points introduced for dynamic analysis).

6. DISPLACEMENT - requests the displacements for a selected set of PHYSICAL points.

7. VELØCITY - requests the velocities for a selected set of PHYSICAL points.

8. HARMØNICS - controls the number of harmonics that will be output for requests associated with the conical shell and hydroelastic problems.

2.3.3 Subcase Definition

In general, a separate subcase is defined for each loading condition. In statics problems separate subcases are also defined for each set of constraints. In complex eigenvalue analysis and frequency response separate subcases are defined for each unique set of direct input matrices. Subcases may be used in connection with output requests, such as in requesting different output for each mode in a real eigenvalue problem.

The Case Control Deck is structured so that a minimum amount of repetition is required. Only one level of subcase definition is provided. All items placed above the subcase level (ahead of the first subcase) will be used for all following subcases, unless overridden within the individual subcase.

In static problems, provision has been made for the combination of the results of several subcases. This is convenient for studying various combinations of individual loading conditions and for the superposition of solutions for symmetrical and antisymmetrical boundaries.

Typical examples of subcase definition are given following a brief description of the cards used in subcase definitions.

The following case control cards are associated with subcase definition:

1. SUBCASE - defines the beginning of a subcase that is terminated by the next subcase delimiters encountered.

2. SUBCØM - defines a combination of two or more immediately preceeding subcases in statics problems. Output requests above the subcase level are used.

3. SUBSEQ - must appear in a subcase defined by SUBCØM to give the coefficients for making the linear combination of the preceeding subcases.

4. SYM - defines a subcase in statics problems for which only output requests within the subcase will be honored. Primarily for use with symmetry problems where the individual parts of the solution may not be of interest.

5. SYMCØM - defines a combination of two or more immediately preceeding SYM subcases in static problems. Output requests above the subcase level are used.

6. SYMSEQ - may appear in a subcase defined by SYMCØM to give the coefficient for making the linear combination of the preceeding SYM subcases. A default value of 1.0 is used if no SYMSEQ card appears.

7. REPCASE - defines a subcase in statics problems that is used to make additional output requests for the previous real subcase. This card is required because multiple output requests for the same item are not permitted in the same subcase. Output requests above the subcase level are still used.

8. MØDES - repeats the subcase in which it appears MØDES times for eigenvalue problems. Used to repeat the same output request for several consecutive modes.

The following examples of Case Control Decks indicate typical ways of defining subcases:

1. Static analysis with multiple loads.

```
ØUTPUT
    DISPLACEMENT = ALL
MPC = 3
    SUBCASE 1
        SPC = 2
        TEMPERATURE(LØAD) = 101
        LØAD = 11
    SUBCASE 2
        SPC = 2
        DEFØRM = 52
        LØAD = 12
    SUBCASE 3
        SPC = 4
        LØAD = 12
    SUBCASE 4
        MPC = 4
        SPC = 4
```

Four subcases are defined in this example. The displacements at all grid points will be printed for all four subcases. MPC = 3 will be used for the first three subcases and will be overridden by MPC = 4 in the last subcase. Since the constraints are the same for subcases 1 and 2 and the subcases are contiguous, the static solutions will be performed simultaneously. In subcase 1, thermal load 101 and external load 11 are internally superimposed, as are the external and deformation loads in subcase 2. In subcase 4 the static loading will result entirely from enforced displacements of grid points.

2. Linear combination of subcases.

```
SPC = 2
ØUTPUT
    SET 1 = 1 THRU 10,20,30
    DISPLACEMENT = ALL
    STRESS = 1
SUBCASE 1
    LØAD = 101
    ØLØAD = ALL
SUBCASE 2
    LØAD = 201
    ØLØAD = ALL
SUBCØM 51
    SUBSEQ = 1.0,1.0
SUBCØM 52
    SUBSEQ = 2.5,1.5
```

Two static loading conditions are defined in subcases 1 and 2. SUBCØM 51 defines the sum of subcases 1 and 2. SUBCØM 52 defines a linear combination consisting of 2.5 times subcase 1 plus 1.5 times subcase 2. The displacements at all grid points and the stresses for the elements numbers in SET will be printed for all four subcases. In addition, the nonzero components of the static load vectors will be printed for subcases 1 and 2.

3. Statics problem with one plane of symmetry.

```
ØUTPUT
    SET 1 = 1,11,21,31,51
    SET 2 = 1 THRU 10, 101 THRU 110
    DISPLACEMENT = 1
    ELFØRCE = 2
SYM 1
    SPC = 11
    LØAD = 21
    ØLØAD = ALL
SYM 2
    SPC = 12
    LØAD = 22
SYMCØM 3
SYMCØM 4
    SYMSEQ 1.0,-1.0
```

Two SYM subcases are defined in subcases 1 and 2. SYMCØM 3 defines the sum and SYMCØM 4 the

difference of the two SYM subcases. The nonzero components of the static load will be printed for subcase 1 and no output is requested for subcase 2. The displacements for the grid point numbers in set 1 and the forces for elements in set 2 will be printed for subcases 3 and 4.

4. Use of REPCASE in statics problems.

```
SET 1 = 1 THRU 10, 101 THRU 110, 201 THRU 210
SET 2 = 21 THRU 30, 121 THRU 130, 221 THRU 230
SET 3 = 31 THRU 40, 131 THRU 140, 231 THRU 240
    SUBCASE 1
        LØAD =10
        SPC = 11
        DISPLACEMENT = ALL
        SPCFØRCE = 1
        ELFØRCE = 1
    REPCASE 2
        ELFØRCE = 2
    REPCASE 3
        ELFØRCE = 3
```

This example defines one subcase for solution and two subcases for output control. The displacements at all grid points and the nonzero components of the single-point forces of constraint along with forces for the elements in SET 1 will be printed for SUBCASE 1. The forces for elements in SET 2 will be printed for REPCASE 2 and the forces for elements in SET 3 will be printed for REPCASE 3.

5. Use of MØDES in eigenvalue problems

```
    METHØD = 2
    SPC = 10
SUBCASE 1
    DISPLACEMENT = ALL
    STRESS = ALL
    MØDES = 2
SUBCASE 3
    DISPLACEMENT = ALL
```

In this example the displacements at all grid points will be printed for all modes. The stresses in all elements will be printed for the first two modes.

2.3.4 Case Control Card Descriptions

The format of the case control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.

4. Brackets [ ] contain an option that may be omitted or included by the user.

5. Underlined options or values are the default values.

6. Physical card consists of information punched in columns 1 thru 72 of a card. Most case control cards are limited to a single physical card.

7. Logical card may have more than 72 columns with the use of continuation cards.

The structure plotter output request packet and the x-y output request packet, while part of the Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Case Control Data Card - ACCELERATIØN - Acceleration Output Request.

Description: Requests form and type of acceleration vector output.

Format and Example(s):

$$\text{ACCELERATIØN}\left[\left(\begin{array}{c}\text{SØRT1}\\ \text{SØRT2}\end{array}, \begin{array}{c}\text{PRINT}\\ \text{PUNCH}\end{array}, \begin{array}{c}\text{REAL}\\ \text{IMAG}\\ \text{PHASE}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ n\\ \text{NØNE}\end{array}\right\}$$

ACCELERATIØN = 5

ACCELERATIØN(SØRT2, PHASE) = ALL

ACCELERATIØN(SØRT1, PRINT, PUNCH, PHASE) = 17

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Frequency Response problems.
ALL	Accelerations for all points will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Accelerations for no points will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. Acceleration output is only available for Transient and Frequency Response problems.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. ACCELERATIØN = NØNE allows overriding an overall output request.

Case Control Data Card AXISYMMETRIC - Conical Shell Boundary Conditions or Hydroelastic Harmonics.

Description: Selects boundary conditions for axisymmetric shell problem or specifies the existence of fluid harmonics for hydroelastic problems.

Format and Example(s):

$$\text{AXISYMMETRIC} = \left\{\begin{array}{l}\text{SINE}\\ \text{CØSINE}\\ \text{FLUID}\end{array}\right\}$$

AXISYMMETRIC = CØSINE

Option	Meaning
SINE	Sine boundary conditions will be used.
CØSINE	Cosine boundary conditions will be used.
FLUID	Existence of fluid harmonics.

Remarks:

1. This card is required and used for conical shell problems.
2. If this card is used for hydroelastic problems, at least one harmonic must be specified on the AXIF card.
3. See Section 1.3.6 of User's Manual for a discussion of the conical shell problem.
4. See Section 1.7.1 of User's Manual for a discussion of the hydroelastic formulation.
5. The sine boundary condition will constrain components 1, 3, and 5 at every ring for the zero harmonic.
6. The cosine boundary condition will constrain components 2, 4 and 6 at every ring the zero harmonic.
7. SPC and MPC case control cards may also be used to effect additional constraints.

Case Control Data Card B2PP - Direct Input Damping Matrix Selection.

Description: Selects a direct input damping matrix.

Format and Example(s):

B2PP = name

B2PP = BDMIG

B2PP = B2PP

Option	Meaning
name	BCD name of $[B^2_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. B2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card CMETHØD - Complex Eigenvalue Extraction Method Selection.

Description: Selects complex eigenvalue extraction data to be used by module CEAD.

Format and Example(s):

CMETHØD = n

CMETHØD = 77

Option	Meaning
n	Set identification of EIGC (and EIGP) card (Integer > 0).

Remarks: Eigenvalue extraction data must be selected when extracting complex eigenvalues using Functional Module CEAD.

Case Control Data Card DEFØRM - Element Deformation Static Load.

Description: Selects the Element Deformation Set to be applied to the structural model.

Format and Example(s):

DEFØRM = n

DEFØRM = 27

Option	Meaning
n	Set identification of DEFØRM cards (Integer > 0).

Remarks:

1. DEFØRM bulk data cards will not be used unless selected in the Case Control Deck.
2. DEFØRM is only applicable in statics, inertia relief, differential stiffness, and buckling problems.
3. The total load applied will be the sum of external, (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement loads (SPC).
4. Static, thermal and element deformation loads should have unique identification numbers.

Case Control Data Card DISPLACEMENT - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{DISPLACEMENT} \left[\left(\begin{matrix} \underline{\text{SØRT1}} \\ \text{SØRT2} \end{matrix}, \begin{matrix} \underline{\text{PRINT}} \\ \text{PUNCH} \end{matrix}, \begin{matrix} \underline{\text{REAL}} \\ \text{IMAG} \\ \text{PHASE} \end{matrix} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NØNE} \end{matrix} \right\}$$

DISPLACEMENT = 5

DISPLACEMENT(REAL) = ALL

DISPLACEMENT(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. VECTØR and PRESSURE are alternate forms and are entirely equivalent to DISPLACEMENT.
4. DISPLACEMENT = NØNE allows overriding an overall output request.

Case Control Data Card DLØAD - Dynamic Load Set Selection.

Description: Selects the dynamic load to be applied in a Transient or Frequency Response problem.

Format and Example(s):

DLØAD = n

DLØAD = 73

Option	Meaning
n	Set identification of a DLØAD, RLØAD1, RLØAD2, TLØAD1, or TLØAD2 card (Integer > 0).

Remarks:

1. The above loads will not be used by NASTRAN unless selected in Case Control.
2. RLØAD1 and RLØAD2 may only be selected in a Frequency Response problem.
3. TLØAD1 and TLØAD2 may only be selected in a Transient Response problem.

Case Control Data Card <u>DSCØEFFICIENT</u> - Differential Stiffness Coefficient Set.

<u>Description</u>: Selects the coefficient set for a Differential Stiffness problem.

<u>Format and Example(s)</u>:

DSCØEFFICIENT = $\left\{ \begin{matrix} \text{DEFAULT} \\ n \end{matrix} \right\}$

DSCØEF = 15

DSCØEF = DEFAULT

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of DSFACT card (Integer > 0).

<u>Remarks</u>: 1. DSFACT cards will not be used unless selected.

2. DSCØEFFICIENT must appear in the 2nd Subcase of a differential stiffness problem.

Case Control Data Card <u>ECHØ</u> - Bulk Data Echo Request.

<u>Description</u>: Requests echo of bulk data deck.

<u>Format and Example(s)</u>:

$$\text{ECHØ} \;=\; \left\{ \begin{array}{l} \underline{\text{SØRT}} \\ \text{UNSØRT} \\ \text{BØTH} \\ \text{NØNE} \end{array} \right\}$$

ECHØ = BØTH

ECHØ = SØRT, UNSØRT

Option	Meaning
SØRT	Sorted echo will be printed.
UNSØRT	Unsorted echo will be printed.
BØTH	Both sorted and unsorted echo will be printed.
NØNE	No echo will be printed.

<u>Remarks</u>: 1. If no ECHØ card appears a sorted echo will be printed.

2. If CHKPNT YES a sorted echo will be printed unless ECHØ = NØNE.

Case Control Data Card ELFØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{ELFØRCE} \quad \left[\left(\begin{matrix}\underline{\text{SØRT1}}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\underline{\text{PRINT}}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each element type. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. ALL cannot be used in a Transient problem.
3. On Frequency Response problems any request for SØRT2 output causes all output to be SØRT2.
4. FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
5. ELFØRCE = NØNE allows overriding an overall request.

Case Control Data Card ELSTRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{ELSTRESS}\quad\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \frac{\text{REAL}}{\text{IMAG}}\atop\text{PHASE}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each element type. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stress for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. ALL cannot be used in a Transient problem.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. STRESS is an alternate form and is entirely equivalent to ELSTRESS.
5. ELSTRESS = NØNE allows overriding an overall output request.

Case Control Data Card FØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{FØRCE}\quad\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \frac{\text{REAL}}{\begin{matrix}\text{IMAG}\\ \text{PHASE}\end{matrix}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

FØRCE = ALL

FØRCE(REAL, PUNCH, PRINT) = 17

FØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each element type. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for ALL elements will be output.
n	Set identification of a previously appearing SET card. Only forces whose element identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Forces for no elements will be output.

Remarks:
1. Both PRINT and PUNCH may be requested.
2. ALL cannot be used in a Transient problem.
3. On Frequency Response problems any request for SØRT2 output causes all output to be SØRT2.
4. ELFØRCE is an alternate form and is entirely equivalent to FØRCE.
5. FØRCE = NØNE allows overriding an overall request.

Case Control Data Card FREQUENCY - Frequency Set Selection

Description: Selects the set of frequencies to be solved in Frequency Response problems.

Format and Example(s):

FREQUENCY = n
FREQUENCY = 17

Option	Meaning
n	Set identification of a FREQ, FREQ1 or FREQ2 type card (Integer > 0).

Remarks: 1. The FREQ, FREQ1 or FREQ2 cards will not be used unless selected in Case Control.

2. A frequency set selection is required for a Frequency Response problem.

Case Control Data Card HARMØNICS - Harmonic Printout Control.

Description: Controls number of harmonics output in axisymmetric shell or axisymmetric fluid problems.

Format and Example(s):

$$\text{HARMONICS} = \left\{ \begin{array}{c} \text{ALL} \\ \text{NØNE} \\ n \\ \underline{0} \end{array} \right\}$$

Option	Meaning
ALL	All Harmonics will be output.
NØNE	No Harmonics will be output.
n	Available harmonics up to and including n will be output (Integer $\geq$ 0).

Remarks: If no HARMØNICS card appears in Case Control, only 0 harmonic output will be printed.

Case Control Data Card IC - Transient Initial Condition Set Selection.

Description: To select the initial conditions for Direct Transient problems.

Format and Example(s):

IC = n

IC = 17

Option	Meaning
n	Set identification of TIC card (Integer > 0).

Remarks:

1. TIC cards will not be used (hence no initial conditions) unless selected in Case Control.
2. Initial conditions are not allowed in a Modal Transient problem.

Case Control Data Card K2PP - Direct Input Stiffness Matrix Selection.

Description: Selects a direct input stiffness matrix.

Format and Example(s):

K2PP = name

K2PP = KDMIG

K2PP = K2PP

Option	Meaning
name	BCD name of a $[K^{2d}_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. K2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card LABEL - Output Label.

Description: Defines a BCD label which will appear on the third heading line of each page of NASTRAN printer output.

Format and Example(s):

LABEL = { Any BCD data }

LABEL = STEVEN E. WALL'S PRØBLEM

Remarks:
1. LABEL appearing at the subcase level will label output for that subcase only.
2. LABEL appearing before all subcases will label any outputs which are not subcase dependent.
3. If no LABEL card is supplied, the label line will be blank.
4. LABEL information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card LINE - Data Lines Per Page.

Description: Defines the number of data lines per printed page.

Format and Example(s):

LINE $= \begin{Bmatrix} 50 \\ n \end{Bmatrix}$

LINE = 35

Option	Meaning
n	Number of data lines per page (Integer > 0).

Remarks: 1. If no LINE card appears, 50 is used.

2. For 11 inch paper, 50 is recommended; for 8-1/2 inch paper, 35 is recommended.

Case Control Data Card LØAD - External Static Load Set Selection.

Description: Selects the external static load set to be applied to the structural model.

Format and Example(s):

LØAD = n

LØAD = 15

Option	Meaning
n	Set identification of at least one external load card and hence must appear on at least one FØRCE, FØRCE1, FØRCE2, MØMENT, MØMENT1, MØMENT2, GRAV, PLØAD, PLØAD2, RFØRCE, PRESAX, FØRCEAX, MØMAX, SLØAD, or LØAD card (Integer > 0).

Remarks:

1. The above static load cards will not be used by NASTRAN unless selected in Case Control.

2. A GRAV card cannot have the same set identification number as any of the other loading card types. If it is desired to apply a gravity load along with other static loads, a LØAD bulk data card must be used.

3. LØAD is only applicable in statics, inertia relief, differential stiffness, buckling, and piecewise linear problems.

4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) Loads.

5. Static, thermal and element deformation loads should have unique set identification numbers.

Case Control Data Card M2PP - Direct Input Mass Matrix Selection.

Description: Selects a direct input mass matrix.

Format and Example(s):

M2PP = name

M2PP = MDMIG

M2PP = M2PP

Option	Meaning
name	BCD name of a $[M^{2d}_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. M2PP is supported only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card MAXLINES - Maximum Number of Output Lines.

Description: Sets the maximum number of output lines to a given value.

Format and Example(s):

$$\text{MAXLINES} = \left\{ \frac{20000}{n} \right\}$$

MAXLINES = 50000

Option	Meaning
n	Maximum number of output lines which the user wishes to allow (Integer > 0).

Remarks:

1. Any time this number is exceeded, NASTRAN will terminate thru PEXIT.
2. This does not override any system MAXLINES parameters such as those on JØB cards or space requests.

Case Control Data Card METHØD - Real Eigenvalue Extraction Method Selection.

Description: Selects the Real Eigenvalue Parameters to be used by the READ module.

Format and Example(s):

METHØD = n

METHØD = 33

Option	Meaning
n	Set identification number of an EIGR card (normal modes or modal formulation) or an EIGB card (buckling). (Integer > 0)

Remarks: An eigenvalue extraction method must be selected when extracting real eigenvalues using Functional Module READ.

Case Control Data Card MØDES - Duplicate Case Control.

Description: Repeats case control MØDES times - to allow control of output in eigenvalue problems.

Format and Example(s):

MØDES = n

MØDES = 1

Option	Meaning
n	Number of modes, starting with the first and proceeding sequentially upward, for which the case control or subcase control is to apply. (Integer > 0).

Remarks:

1. This card can be illustrated by an example. Suppose stress output is desired for the first five modes only and Displacements only thereafter. The following example would accomplish this:

```
SUBCASE 1
MØDES = 5
ØUTPUT
STRESS = ALL
SUBCASE 6
ØUTPUT
DISPLACEMENTS = ALL
BEGIN BULK
```

2. The MØDES card causes the results for each eigenvalue to be considered as a separate, successively numbered subcase, beginning with the subcase number containing the MØDES card.

3. If the MØDES card is not used, eigenvalue results are considered to be a part of a single subcase. Hence, any output requests for the single subcase will apply for all eigenvalues.

4. All eigenvectors with mode numbers greater than the number of records in Case Control are printed with the descriptors of the last Case Control record. For example, to suppress all printout for modes beyond the first three, the following Case Control deck could be used:

```
SUBCASE 1
MØDES = 3
DISPLACEMENTS = ALL
SUBCASE 4
DISPLACEMENTS = NØNE
BEGIN BULK
```

Case Control Data Card MPC - Multipoint Constraint Set Selection.

Description: Selects the multipoint constraint set to be applied to the structural model.

Format and Example(s):

MPC = n

MPC = 17

Option	Meaning
n	"n" is the set identification of a Multipoint-Constraint Set and hence must appear on at least one MPC or MPCADD card. (Integer > 0).

Remarks: MPC or MPCADD cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card NLLØAD - Nonlinear Load Output Request.

Description: Requests form and type of nonlinear load output for Transient problems.

Format and Example(s):

$$\text{NLLØAD } [(\frac{\text{PRINT}}{\text{PUNCH}})] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

NLLØAD = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Nonlinear loads for all solution points will be output.
NØNE	Nonlinear loads will not be output.
n	Set identification of previously appearing SET card. (Integer > 0). Only nonlinear loads for points whose identification numbers appear on this SET card will be output.

Remarks:

1. Nonlinear loads are output only in the solution (D or H) set.
2. The output will have a SØRT2 format.
3. Both PRINT and PUNCH may be used.
4. NLLØAD = NØNE allows overriding an overall output request.

Case Control Data Card NØNLINEAR - Nonlinear Load Set Selection.

Description: Selects nonlinear load for transient problems.

Format and Example(s):

NØNLINEAR = n

NØNLINEAR LØAD SET = 75

Option	Meaning
n	Set identification of NØLINi cards (Integer > 0)

Remarks: NØLINi cards will not be used unless selected in Case Control.

Case Control Data Card ØFREQUENCY - Output Frequency Set.

Description: Selects from the solution set of frequencies a subset for output requests.

Format and Example(s):

$$\text{ØFREQUENCY} = \left\{ \begin{array}{c} \underline{\text{ALL}} \\ \text{n} \end{array} \right\}$$

ØFREQUENCY = ALL

ØFREQUENCY SET = 15

Option	Meaning
ALL	Output for all frequencies will be printed out.
n	Set identification of previously appearing SET card. (Integer > 0). Output for frequencies closest to those given on this SET card will be output.

Remarks: ØFREQUENCY is defaulted to ALL if it is not supplied.

Case Control Data Card ØLØAD - Applied Load Output Request

Description: Requests form and type of applied load vector output.

Format and Example(s):

$$\text{ØLØAD} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \begin{matrix} \underline{\text{REAL}} \\ \text{IMAG} \\ \text{PHASE} \end{matrix} \right) \right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

ØLØAD = ALL

ØLØAD(SØRT1, PHASE) = 5

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Applied loads for all points will be output. (SØRT1 will only output nonzero values).
NØNE	Applied loads for no points will be output.
n	Set identification of previously appearing SET card. Only loads on points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. In a Statics problem a request for SØRT2 causes loads at all points (zero and non-zero) to be output.
4. ØLØAD = NØNE allows overriding an overall output request.

Case Control Data Card ØUTPUT - Output Packet Delimiter.

Description: Delimits the various output packets, structure plotter, curve plotter, and printer/punch.

Format and Example(s):

$$\text{ØUTPUT}\left[\begin{pmatrix}\text{PLØT}\\\text{XYØUT}\\\text{XYPLØT}\end{pmatrix}\right]$$

ØUTPUT

ØUTPUT(PLØT)

ØUTPUT(XYØUT)

Option	Meaning
No qualifier	Beginning of printer output packet - this is not a required card.
PLØT	Beginning of structure plotter packet. This card must preceed all structure plotter control cards.
XYØUT or XYPLØT	Beginning of curve plotter packet. This card must precede all curve plotter control cards. XYPLØT and XYØUT are entirely equivalent.

Remarks:

1. The structure plotter packet and the curve plotter packet must be at the end of the Case Control Deck. Either may come first.

2. The delimiting of a printer packet is completely optional.

Case Control Data Card PLCØEFFICIENT - Piecewise Linear Coefficient Set.

Description: Selects the coefficient set for Piecewise Linear problems.

Format and Example(s):

$$\text{PLCØEFFICIENT} = \begin{Bmatrix} \text{DEFAULT} \\ n \end{Bmatrix}$$

PLCØEFFICIENT = DEFAULT

PLCØEFFICIENT = 25

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of PLFACT card (Integer > 0).

Remarks: PLFACT cards will not be used unless selected.

Case Control Data Card PLØTID - Plotter Identification.

Description: Defines BCD identification which will appear on the first frame of any NASTRAN plotter output.

Format and Example(s):

PLØTID = { Any BCD data }

PLØTID = MSC - BLDG. 125 BØX 91 - - RETURN TØ MACNEAL-SCHWENDLER CØRP.

Remarks:

1. PLØTID must appear before the ØUTPUT(PLØT) or ØUTPUT(XYØUT) cards.
2. The presence of PLØTID causes a special header frame to be plotted with the supplied identification plotted several times. This allows easy identification of NASTRAN plotter output.
3. If no PLØTID card appears, no ID frame will be plotted.
4. The PLØTID header frame will not be generated for the table plotters.

Case Control Data Card PRESSURE - Hydroelastic Pressure Output Request.

Description: Requests form and type of displacement and hydroelastic pressure vector output.

Format and Example(s):

$$\text{PRESSURE}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\frac{\text{IMAG}}{\text{PHASE}}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

PRESSURE = 5

PRESSURE(IMAG) = ALL

PRESSURE(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements and pressures for all points will be output.
NØNE	Displacements and pressures for no points will be output.
n	Set identification of previously appearing SET card. Only displacements and pressures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. DISPLACEMENT and VECTØR are alternate forms and are entirely equivalent to PRESSURE.
4. PRESSURE = NØNE allows overriding an overall output request.

Case Control Data Card RANDØM - Random Analysis Set Selection

Description: Selects the RANDPS and RANDTi cards to be used in Random Analysis.

Format and Example(s):

RANDØM = n

RANDØM = 177

Option	Meaning
n	Set identification of RANDPS and RANDTi cards to be used in RANDØM analysis (Integer > 0).

Remarks:

1. RANDPS cards must be selected to do Random Analysis.
2. RANDPS must be selected in the first subcase of the current loop. RANDPS may not reference subcases in a different loop.

Case Control Data Card REPCASE - Repeat Case Subcase Delimiter.

Description: Delimits and identifies a repeated subcase.

Format and Example(s):

REPCASE n

REPCASE 137

Option	Meaning
n	Subcase number (Integer > 1).

Remarks:

1. "n" must be strictly increasing (i.e. greater than all previous subcase set identification numbers).
2. This case will only re-output the previous real case. This allows additional set specification.
3. REPCASE may only be used in Statics or Inertia Relief.
4. One or more repeated subcases (REPCASEs) must immediately follow the subcase (SUBCASE) to which they refer. (See example 4 in Section 2.3.3).

Case Control Data Card SACCELERATIØN - Solution Set Acceleration Output Request

Description: Requests form and type of solution set acceleration output.

Format and Example(s):

$$\text{SACCELERATIØN}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\text{IMAG}}\ \text{PHASE}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

SACCELERATIØN = ALL

SACCELERATIØN(PUNCH, IMAG) = 142

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Frequency Response problems.
ALL	Acceleration for all solution points (modes) will be output.
NØNE	Acceleration for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0)

Remarks:

1. Both PRINT and PUNCH may be requested.
2. Acceleration output is only available for Transient and Frequency Response problems.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. SACCELERATIØN = NØNE allows overriding an overall output request.

Case Control Data Card SDAMPING - Structural Damping.

Description: Selects table which defines damping as a function of frequency in Modal Formulation problems.

Format and Example(s):

SDAMPING = n

SDAMPING = 77

Option	Meaning
n	Set identification of a TABDMP1 table (Integer > 0).

Remarks: If SDAMPING is not used BHH = [0].

Case Control Data Card <u>SDISPLACEMENT</u> - Solution Set Displacement Output Request.

<u>Description</u>: Requests form and type of solution set displacement output.

<u>Format and Example(s)</u>:

$$\text{SDISPLACEMENT} \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\begin{matrix}\text{IMAG}\\ \text{PHASE}\end{matrix}} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

SDISPLACEMENT = ALL

SDISPLACEMENT(SØRT2, PUNCH, PHASE) = NØNE

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

<u>Remarks</u>:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. SVECTØR is an alternate form which is entirely equivalent to SDISPLACEMENT.
4. SDISPLACEMENT = NØNE allows overriding an overall output request.

Case Control Data Card SET - Set Definition Card.

Description: 1) Lists identification numbers (point or element) for output requests.
2) Lists the frequencies for which output will be printed in Frequency Response Problems.

Format and Example(s):

1) SET n = $\{i_1[,i_2,\ i_3$ THRU i_4 EXCEPT $i_5,\ i_6,\ i_7,\ i_8$ THRU $i_9]\}$

SET 77 = 5

SET 88 = 5, 6, 7, 8, 9, 10 THRU 55 EXCEPT 15, 16, 77,
78, 79, 100 THRU 300

SET 99 = 1 THRU 100000

2) SET n = $\{r_1\ [,\ r_2,\ r_3,\ r_4]\}$

SET 101 = 1.0, 2.0, 3.0

SET 105 = 1.009, 10.2, 13.4,
14.0, 15.0

Option	Meaning
n	Set identification (Integer > 0). Any set may be redefined by reassigning its identification number. Sets inside SUBCASE delimiters are local to the SUBCASE.
i_1, i_2 etc.	Element or point identification number at which output is requested. (Integer > 0) If no such identification number exists, the request is ignored.
i_3 THRU i_4	Output at set identification numbers i_3 thru i_4 $(i_4 > i_3)$.
EXCEPT	Set identification numbers following EXCEPT will be deleted from output list as long as they are in the range of the set defined by the immediately preceding THRU.
r_1, r_2 etc.	Frequencies for output (Real > 0.0). The nearest solution frequency will be output. EXCEPT and THRU cannot be used.

Remarks:

1. A SET card may be more than one physical card. A comma (,) at the end of a physical card signifies a continuation card. Commas may not end a set.

2. Set identification numbers following EXCEPT within the range of the THRU must be in ascending order.

Case Control Data Card SPC - Single-Point Constraint Set Selection.

Description : Selects the single-point constraint set to be applied to the structural model.

Format and Example(s):

SPC = n

SPC = 10

Option	Meaning
n	Set identification of a single-point constraint set and hence must appear on a SPC, SPC1 or SPCADD card (Integer > 0).

Remarks: SPC, SPC1 or SPCADD cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card SPCFØRCES - Single-Point Forces of Constraint Output Request.

Description: Requests form and type of Single-Point Force of constraint vector output.

Format and Example(s):

$$\text{SPCF\O RCES} \quad \left[\left(\frac{\text{S\O RT1}}{\text{S\O RT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\begin{matrix}\text{IMAG}\\ \text{PHASE}\end{matrix}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{N\O NE}\end{matrix}\right\}$$

SPCFØRCES = 5

SPCFØRCES(SØRT2, PUNCH, PRINT, IMAG) = ALL

SPCFØRCES(PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Single-Point forces of constraint for all points will be output. (SØRT1 will only output nonzero values.)
NØNE	Single point forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only single-point forces constraint for points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. In a Statics problem a request for SØRT2 causes loads at all points (zero and non-zero) to be output.
4. SPCFØRCES = NØNE allows overriding an overall output request.

Case Control Data Card STRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{STRESS} \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \begin{matrix}\underline{\text{REAL}}\\ \underline{\text{IMAG}}\\ \text{PHASE}\end{matrix}\right)\right] = \begin{Bmatrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{Bmatrix}$$

STRESS = 5

STRESS = ALL

STRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each element type. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stresses for no points will be output.

Remarks:
1. Both PRINT and PUNCH may be requested.
2. ALL cannot be used in a Transient problem.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. ELSTRESS is an alternate form and is entirely equivalent to STRESS.
5. STRESS = NØNE allows overriding an overall output request.

Case Control Data Card SUBCASE - Subcase Delimiter.

Description: Delimits and identifies a subcase.

Format and Example(s):

SUBCASE n

SUBCASE 101

Option	Meaning
n	Subcase identification number (Integer > 0).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).

2. Plot requests and RANDØM requests refer to n.

Case Control Data Card SUBCØM - Combination Subcase Delimiter.

Description: Delimits and identifies a combination subcase.

Format and Example(s):

SUBCØM n

SUBCØM 125

Option	Meaning
n	Subcase identification number (Integer > 2).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. A SUBSEQ card must appear in this subcase.
3. SUBCØM may only be used in Statics or Inertia Relief problems.
4. Output requests above the subcase level will be utilized.

Case Control Data Card SUBSEQ - Subcase Sequence Coefficients.

Description: Gives the coefficients for forming a linear combination of the previous subcases.

Format and Example(s):

SUBSEQ = R_1 [, R_2, R_3, . . ., R_N]
SUBSEQ = 1.0, -1.0, 0.0, 2.0

Option	Meaning
R_1 to R_N	Coefficients of the previously occuring subcases (Real).

Remarks:

1. A SUBSEQ card must only appear in a SUBCØM subcase.
2. A SUBSEQ card may be more than one physical card. A comma at the end signifies a continuation card.
3. SUBSEQ may only be used in Statics or Inertia Relief problems.

Case Control Data Card SUBTITLE - Output Subtitle.

Description: Defines a BCD subtitle which will appear on the second heading line of each page of NASTRAN printer output.

Format and Example(s):

SUBTITLE = { Any BCD data }

SUBTITLE = NASTRAN PRØBLEM NØ. 5-1A

Remarks:

1. SUBTITLE appearing at the subcase level will title output for that subcase only.
2. SUBTITLE appearing before all subcases will title any outputs which are not subcase dependent.
3. If no SUBTITLE card is supplied, the subtitle line will be blank.
4. SUBTITLE information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card SVECTØR - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SVECTØR} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\text{IMAG}} \atop \text{PHASE}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$$

SVECTØR = ALL

SVECTØR(SØRT2, PUNCH, PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. SDISPLACEMENT is an alternate form and is entirely equivalent to SVECTØR.
4. SVECTØR = NØNE allows overriding an overall output request.

Case Control Data Card SVELØCITY - Solution Set Velocity Output Request

Description: Requests form and type of solution set velocity output.

Format and Example(s):

$$\text{SVEL\O CITY}\left[\left(\frac{\text{S\O RT1}}{\text{S\O RT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \begin{array}{c}\underline{\text{REAL}}\\ \underline{\text{IMAG}}\\ \text{PHASE}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ n\\ \text{N\O NE}\end{array}\right\}$$

SVELØCITY = 5

SVELØCITY(SØRT2, PUNCH, PRINT, PHASE) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° < \text{phase} < 360.0°$) on Frequency Response problems.
ALL	Velocity for all solution points (modes) will be output.
NØNE	Velocity for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. Velocity output is only available for Transient and Frequency Response problems.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. SVELØCITY = NØNE allows overriding an overall output request.

Case Control Data Card SYM - Symmetry Subcase Delimiter.

Description: Delimits and identifies a symmetry subcase.

Format and Example(s):

SYM n

SYM 123

Option	Meaning
n	Subcase identification number (Integer > 0).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. Plot requests and RANDØM requests should refer to n.
3. Overall output requests will not propagate into a SYM subcase (i.e. any output desired must be requested within the subcase).
4. SYM may only be used in Statics or Inertia Relief.

Case Control Data Card SYMCØM - Symmetry Combination Subcase Delimiter.

Description: Delimits and identifies a symmetry combination subcase.

Format and Example(s):

SYMCØM n

SYMCØM 123

Option	Meaning
n	Subcase identification number (Integer > 2).

Remarks:

1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
2. SYMCØM may only be used in Statics or Inertia Relief problems.

Case Control Data Card SYMSEQ - Symmetry Sequence Coefficients.

Description: Gives the coefficients for combining the symmetry subcases into the total structure.

Format and Example(s):

SYMSEQ = R_1[, R_2, R_3 --- R_n]

SYMSEQ = 1.0, -2.0, 3.0, 4.0

Option	Meaning
R_1 to R_N	Coefficients of the previously occurring N SYM subcases (Real).

Remarks:

1. A SYMSEQ card may only appear in a SYMCØM subcase.
2. The default value for the coefficients is 1.0 if no SYMSEQ card appears.
3. A SYMSEQ card may consist of more than one physical card.
4. SYMSEQ may only be used in Statics or Inertia Relief.

Case Control Data Card TEMPERATURE - Thermal Properties Set Selection.

Description: Selects the temperature set to be used in either material property calculation or thermal loading.

Format and Example(s):

$$\text{TEMPERATURE}\left[\begin{pmatrix}\text{MATERIAL}\\ \text{LØAD}\\ \underline{\text{BØTH}}\end{pmatrix}\right] = n$$

TEMPERATURE(LØAD) = 15

TEMPERATURE(MATERIAL) = 7

TEMPERATURE = 7

Option	Meaning
MATERIAL	The selected temperature table will be used to determine temperature-dependent material properties indicated on the MATTi type cards.
LØAD	The selected temperature table will be used to determine an equivalent static load.
BØTH	Both options, MATERIAL and LØAD will use the same temperature table.
n	Set identification number of TEMP, TEMPD, TEMPP1, TEMPP2, TEMPP3, TEMPRB, or TEMPAX cards (Integer > 0).

Remarks:

1. Only one temperature-dependent material request may be made in any problem and must be above the subcase level.
2. Thermal loading may only be used in Statics, Inertia Relief, Differential Stiffness, and Buckling problems.
3. Temperature-dependent materials may not be used in Piecewise Linear problems.
4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) loads.
5. Static, thermal and element deformation loads should have unique set identification numbers.

Case Control Data Card TFL - Transfer Function Set Selection.

Description: Selects the Transfer function set to be added to the direct input matrices.

Format and Example(s):

TFL = n

TFL = 77

Option	Meaning
n	Set identification of a TF card (Integer > 0).

Remarks:

1. Transfer functions will not be used unless selected in the Case Control Deck.
2. Transfer functions are supported on dynamics problems only.
3. Transfer functions are simply another form of direct matrix input.

Case Control Data Card THERMAL - Temperature Output Request.

Description: Requests form and type of temperature vector output.

Format and Example(s):

$$\text{THERMAL} \left[\begin{pmatrix}\text{PRINT}\\ \text{PUNCH}\end{pmatrix}\right] = \begin{Bmatrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{Bmatrix}$$

THERMAL = 5

THER(PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Temperatures for all points will be output.
NØNE	Temperatures for no points will be output.
n	Set identification of previously appearing SET card. Only temperatures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. THERMAL output request is designed for use with the Heat Transfer option. The printed output will have temperature headings and the punched output will be TEMP bulk data cards. The SID on a bulk data card will be the subcase number (= 1 if no defined subcases).

2. Both PRINT and PUNCH may be requested.

Case Control Data Card TITLE - Output Title.

Description: Defines a BCD title which will appear on the first heading line of each page of NASTRAN printer output.

Format and Example(s):

TITLE = { Any BCD data }

TITLE = **$// ABCDEFGHI .... $

Remarks:

1. TITLE appearing at the subcase level will title output for that subcase only.
2. TITLE appearing before all subcases will title any outputs which are not subcase dependent.
3. If no TITLE card is supplied, the title line will contain data and page numbers only.
4. TITLE information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card TSTEP - Transient Time Step Set Selection.

Description: Selects integration and output time steps for Transient problems.

Format and Example(s):

TSTEP = n

TSTEP = 731

Option	Meaning
n	Set identification of a selected TSTEP bulk data card (Integer > 0).

Remarks: 1. A TSTEP card must be selected to execute a Transient problem.

2. Only one TSTEP card may have this value of n.

Case Control Data Card VECTØR - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{VECTØR} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \frac{\text{REAL}}{\begin{matrix}\text{IMAG}\\ \text{PHASE}\end{matrix}} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

VECTØR = 5

VECTØR(REAL) = ALL

VECTØR(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of a previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
3. DISPLACEMENT and PRESSURE are alternate forms and are entirely equivalent to VECTØR.
4. VECTØR = NØNE allows overriding an overall output request.

Case Control Data Card <u>VELØCITY</u> - Velocity Output Request.

<u>Description</u>: Requests form and type of velocity vector output.

<u>Format and Example(s)</u>:

$$\text{VELØCITY} \quad \left[\left(\frac{\text{SØRT1}}{\text{SØRT2}}, \frac{\text{PRINT}}{\text{PUNCH}}, \begin{array}{c}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{array}\right)\right] = \begin{Bmatrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{Bmatrix}$$

VELØCITY = 5

VELØCITY(SØRT2, PHASE, PUNCH) = ALL

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Frequency Response problems.
ALL	Velocity for all solution points will be ouptut.
NØNE	Velocity for no solution points will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

<u>Remarks</u>:

1. Both PRINT and PUNCH may be requested.
2. Velocity output is only available for Transient and Frequency Response problems.
3. On a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
4. VELØCITY = NØNE allows overriding an overall output request.

2.4 BULK DATA DECK

The primary NASTRAN input medium is the Bulk Data card. These cards are used to define the structural model and various pools of data which may be selected by Case Control at execution time.

For large problems the Bulk Data Deck may consist of several thousand cards. In order to minimize the handling of large numbers of cards, provision has been made in NASTRAN to store the bulk data on the Problem Tape, from which it may be modified on subsequent runs. A User's Master File (Section 2.5) is also provided for the storage of Bulk Data Decks.

For any cold start, the entire Bulk Data Deck must be submitted. Thereafter, if the original run was checkpointed, the Bulk Data Deck exists on the Problem Tape in sorted form where it may be modified and reused on restart. On restart the bulk data cards contained in the Bulk Data Deck are added to the bulk data contained on the Old Problem Tape. Cards are removed from the Old Problem Tape (or the User's Master File) by the use of a delete card. Cards to be deleted are indicated by inserting a bulk data card with a / in column one and the sorted bulk data sequence numbers in fields two and three. All bulk data cards in the range of the sequence numbers in fields two and three will be deleted. In the case where only a single card is deleted, field three may be left blank.

The Bulk Data Deck may be submitted with the cards in any order as a sort is performed prior to the execution of the Input File Processor. It should be noted that the machine time to perform this is minimized for a deck that is already sorted. The sort time for a badly sorted deck will become significant for large decks. The user may obtain a printed copy of either the unsorted or sorted bulk data by selection in the Case Control Deck. A sorted echo is necessary in order to make modifications on a secondary execution using the Problem Tape. This echo is automatically provided unless specifically suppressed by the user.

2.4.1 Format of Bulk Data Cards

The bulk data card format is variable to the extent that any quantity except the mnemonic can be punched anywhere within a specified 8 or 16-column field. The normal card uses an 8-column field as indicated in the following diagram:

Small Field Bulk Data Card

1a	2	3	4	5	6	7	8	9	10a
8	8	8	8	8	8	8	8	8	8

The mnemonic is punched in field 1 beginning in column 1. Fields 2-9 are for data items. The only limitations in data items are that they must lie completely within the designated field, have no imbedded blanks, and must be of the proper type, i.e., blank, integer, real, double precision, or BCD*. All real numbers, including zero, must contain a decimal point. A blank will be interpreted as a real zero or integer zero as required. Real numbers may be encoded in various ways. For example, the real number 7.0 may be encoded as 7.0, .7E1, 0.7+1, 70.-1, .70+1, etc. A double precision number must contain both a decimal point and an exponent with the character D such as 7.0D0. Double precision data values are only allowed in a few situations, such as on the PARAM card. BCD data values consist of one to eight alphanumeric characters, the first of which must be alphabetic.

Normally field 10 is reserved for optional user identification. However, in the case of continuation cards field 10 (except column 73 which is not referenced) is used in conjunction with field 1 of the continuation card as an identifier and hence must contain a unique entry. The continuation card contains the symbol + in column 1 followed by the same seven characters that appeared in columns 74-80 of field 10 of the card that is being continued. This allows the data to be submitted as an unsorted deck.

The small field data card should be more than adequate for the kinds of data normally associated with structural engineering problems. Since abbreviated forms of floating point numbers are allowed, up to seven significant decimal digits may be used in an eight-character field. Occasionally, however, the input is generated by another computer program or is available in a form where a wider field would be desirable. For this case, the larger field format with a 16-character data field is provided. Each logical card consists of two physical cards as indicated in the following diagram:

*See SEQGP and SEQEP for exceptions.

Large Field Bulk Data Card

1a	2	3	4	5	10a
8	16	16	16	16	8

1b	6	7	8	9	10b
8	16	16	16	16	8

The large field card is denoted by placing the symbol * after the mnemonic in field 1a and some unique character configuation in the last 7 columns of field 10a. The second physical card contains the symbol * in column 1 followed by the same seven characters that appeared after column 73 in field 10a of the first card. The second card may in turn be used to point to a large or small field continuation card, depending on whether the continuation card contains the symbol * or the symbol + in column 1. The use of multiple and large field cards are illustrated in the following examples:

Small Field Card with Small Field Continuation Card.

TYPE									QED123
+ED123									

Large Field Card

TYPE*					QED124
*ED124					

Large Field Card with Large Field Continuation Card

TYPE*					QED301
*ED301					QED302
*ED302					QED305
*ED305					

Large Field Card Followed by a Small Field Continuation Card and a Large Field Continuation Card

TYPE*					QED462
*ED462					QED421
+ED421					QED361
*ED361					QED291
*ED291					

Small Field Card with Large Field Continuation Card

TYPE									QED632
*ED632									QED204
*ED204									

In the above examples column 73 arbitrarily contains the symbol Q in all cases where field 10 is used as a pointer. However, column 73 could have been left blank or the same symbol used in column 1 of the following card could have been used (i.e., the symbols * or +).

2.4.2 Bulk Data Card Descriptions

The detailed descriptions of the bulk data cards are contained in this section in alphabetical order. For details pertaining to the use of each card and for a discussion of the cards in functional groups, the user is referred to Section 1 - Structural Modeling. Small field examples are given for each card along with a description of the contents of each field. In the Format and Example section of each card description, both a symbolic card format description and an example of an actual card are shown. Literal constants are shown in the card format section enclosed in quotes (e.g., "0"). Fields that are required to be blank are indicated in the card format section by whenever they are followed by nonblank fields or whenever such notation will clarify the card description.

The Input File Processor will produce error messages for any cards that do not have the proper format or which contain illegal data.

Continuation cards need not be present unless they contain required data. In the case of multiple continuation cards, the intermediate cards must be present (even though fields 2-9 are blank) if one of the following cards contains data in fields 2-9.

Input Data Card $\underline{\$}$ Comment

Description: For user convenience in inserting commentary material into the unsorted echo of his input Bulk Data Deck. The $ card is otherwise ignored by the program. These cards will not appear in a sorted echo nor will they exist on the New Problem Tape.

Format and Example:

1	2	3	4	5	6	7	8	9	10
$	followed	by any l	egitimate	charact	ers in ca	rd column	s 2-80		
$	THIS IS	A REMARK	(*,'$$)-	+/					

Input Data Card /   Delete

Description: Delete cards are used to remove cards from either the Old Problem Tape on restart or the User's Master File.

Format and Example:

1	2	3	4	5	6	7	8	9	10
/	K1	K2							
/	4								

Field	Contents
K1	Sorted sequence number of first card in sequence to be removed
K2	Sorted sequence number of last card in sequence to be removed

Remarks:
1. The delete card causes bulk data cards having sort sequence numbers K1 thru K2 to be removed from the Bulk Data Deck.
2. If K2 is blank, only card K1 is removed from the Bulk Data Deck.
3. If neither an Old Problem Tape nor a User's Master File are used in the current execution, the delete cards are ignored.

Input Data Card ADUMi   Dummy Element Attributes

Description: Defines attributes of the dummy elements ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
ADUMi	NG	NC	NP	ND					
ADUM2	8	2	1	3					

Field

NG — Number of grid points connected by DUMi dummy element (Integer > 0)

NC — Number of additional entries on CDUMi connection card (Integer $\geq$ 0)

NP — Number of additional entries on PDUMi property card (Integer $\geq$ 0)

ND — Number of displacement components at each grid point used in generation of differential stiffness matrix (Integer 3 or 6)

Input Data Card ASET Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET	ID	C	ID	C	ID	C	ID	C	
ASET	16	2	23	3516			1	4	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks:

1. Coordinates specified on ASET cards may not be specified on ØMIT, ØMIT1, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multipoint constraint relations (MPC) or as permanent single-point constraints on a GRID card.
2. As many as 24 coordinates may be placed in the analysis set by a single card.
3. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the Ø-set.

Input Data Card ASET1 Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET1	C	G	G	G	G	G	G	G	abc
ASET1	345	2	1	3	10	9	6	5	ABC

+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ASET1	C	ID1	"THRU"	ID2					
ASET1	123456	7	THRU	109					

Field	Contents
C	Component number (any unique combination of the digits 1-6 [with no imbedded blanks] when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points).
G,ID1,ID2	Grid or scalar point identification numbers (Integer > 0, ID1 < ID2)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multi-point constraint relation (MPC card), nor may it be referenced on an SPC, SPC1, ØMIT, ØMIT1, ASET, or SUPØRT card or on a GRID card as permanent single-point constraints.

2. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the Ø-set.

3. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

Input Data Card AXIC   Conical Shell Problem "Flag"

Description: Defines the existence of an axisymmetric conical shell problem.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIC	H								
AXIC	15								

Field	Contents
H	Highest harmonic defined for the problem ($0 \leq$ Integer ≤ 998)

Remarks: 1. Only one (1) AXIC card is allowed. When the AXIC card is present, most other cards are not allowed. The types which are allowed with the AXIC card are listed below:

CCØNEAX	MAT1	SPCAX
DAREA	MATT1	SUPAX
DELAY	MØMAX	TABDMP1
DLØAD	MØMENT	TABLED1
DMI	MPCADD	TABLED2
DMIG	MPCAX	TABLED3
DPHASE	NØLIN1	TABLED4
DSFACT	NØLIN2	TABLEM1
EIGB	NØLIN3	TABLEM2
EIGC	NØLIN4	TABLEM3
EIGP	ØMITAX	TABLEM4
EIGR	PARAM	TEMPAX
EPØINT	PCØNEAX	TF
FØRCE	PØINTAX	TIC
FØRCEAX	PRESAX	TLØAD1
FREQ	RINGAX	TLØAD2
FREQ1	RLØAD1	TSTEP
FREQ2	RLØAD2	
GRAV	SECTAX	
LØAD	SPCADD	

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card AXIF Fluid Related Axisymmetric Parameters

Description: Defines basic parameters and the existence of an axisymmetric fluid analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIF	CID	G	DRHØ	DB	NØSYM	F			abc
AXIF	2	32.2	0.12	2.5+5	YES				CARD-1

+bc	N1	N2	N3	N4	N5	N6	N7	N8	def
+ARD-1	1	2	3		4		7	10	

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni						def
+ARD-1	0	THRU	10						

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni	"STEP"	NS				def
+ARD-1	0	THRU	9	STEP	3				

-etc.-

Field	Contents
CID	Fluid Coordinate System identification number (Integer > 0)
G	Value of gravity for fluid elements in axial direction (Real)
DRHØ	Default mass density for fluid elements (Real > 0.0 or blank)
DB	Default bulk modulus for fluid elements (Real)
NØSYM	Request for nonsymmetric (sine) terms of series (BCD: "YES" or "NO")
F	Flag specifing harmonics (Blank - harmonic specified, or BCD - "NØNE")
Nn	Harmonic numbers for solution, an increasing sequence of integers. On the standard continuation card blanks are ignored. On the alternate form continuation cards, "THRU" implies all numbers including upper and lower integer (Blank, or integer, $0 \leq Nn < 100$, or BCD: "THRU" or "STEP")
NS	Every NSth step of the harmonic numbers specified in the "THRU" range is used for solution (Integer if field 5 is "STEP", $Ni = I \cdot NS + N1$ where I is an integer)

Remarks:

1. Only one (1) AXIF card is allowed.

2. CID must reference a cylindrical or spherical coordinate system.

3. Positive gravity (+G) implies that the direction of free fall is in the -Z direction of the Fluid Coordinate System.

4. The DRHØ value replaces blank values of RHØ on the FSLIST, BDYLIST and CFLUIDi cards.

5. The DB value replaces blank values of B on the CFLUIDi cards. If the CFLUIDi entry is blank and DB is zero or blank, the fluid is incompressible.

6. If NØSYM=YES, both sine and cosine terms are specified. If NØSYM=NØ, only cosine terms are specified.

(Continued)

AXIF (cont.)

7. If F = NØNE, no harmonics are specified, no fluid elements are necessary, and no continuation cards may be present.

Example:

1	2	3	4	5	6	7	8	9	10
AXIF	100	-386.0		0.0	NØ				+1
+1	0	THRU	50	STEP	5				+2
+2	52								+3
+3	54	THRU	57						+4
+4	61	THRU	65						+5
+5	68		71		72	75			+6
+6	81	92							END

Input Data Card AXSLØT   Axisymmetric slot analysis parameter

Description: Defines the harmonic index and the default values for acoustic analysis cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXSLØT	RHØD	BD	N	WD	MD				
AXSLØT	0.003	1.5+2	3	0.75	6				

Field	Contents
RHØD	Default density of fluid-mass/volume (Real ≠ 0.0 or blank)
BD	Default bulk modulus of fluid = (force/volume ratio change) (Real ≥ 0.0 or blank)
N	Harmonic index number (Integer ≥ 0)
WD	Default slot width (Real ≥ 0.0 or blank)
MD	Default number of slots (Integer ≥ 0 or blank)

Remarks:

1. No more than one AXSLØT card is permitted.

2. The default values are used on the GRIDS, SLBDY, CAXIFi, and CSLØTi data cards and must be nonzero as noted if these cards use the default.

3. The harmonic index number N must be entered on this card.

4. If the number of slots, M, is different in different regions or the cavity, this fact may be indicated on the CSLØTi and SLBDY cards. If the number of slots is zero, no matrices for CSLØTi elements are generated.

5. A zero entry for bulk modulus is treated as if the fluid was incompressible.

Input Data Card BARØR   Simple Beam Orientation Default

Description: Defines default values for fields 3 and 6-9 of the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BARØR		PID			X1,GO	X2	X3	F	
BARØR		39			0.6	2.9	-5.87	1	

Field	Contents
PID	Identification number of PBAR property card (Integer > 0 or blank)
X1, X2, X3	Vector components measured in displacement coordinate system at GA to determine (with the vector from end A to end B) the orientation of the element coordinate system for the bar element (Real or blank; see below)
GO	Grid point identification number (Integer > 0; see below)
F	Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = 1	X1	X2	X3
F = 2	GO	blank	blank

Remarks:
1. The contents of fields on this card will be assumed for any CBAR card whose corresponding fields are blank.
2. Only one BARØR card may appear in the user's Bulk Data Deck.
3. For an explanation of bar element geometry, see Section 1.3.2.

Input Data Card BDYLIST Fluid Boundary List

Description: Defines the boundary between a fluid and a structure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
BDYLIST	.037	432	325	416	203	256	175	153	345A

+bc	IDF8	etc.							def
+45A	101	105	AXIS						

-etc.-

Field	Contents
RHØ	Fluid mass density at boundary (Real $\geq$ 0.0 or blank. Default on AXIF card is used if blank)
IDFi	Identification number of a RINGFL point (Integer > 0 or BCD. "AXIS" may be first and/or last entry on the logical card)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Each logical card defines a boundary if RHØ $\neq$ 0.0. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.
3. The BCD word, AXIS, defines an intersection with the polar axis of the fluid coordinate system.
4. There may be as many BDYLIST cards as the user requires. If the fluid density varies along the boundary there must be one BDYLIST card for each interval between fluid points.
5. The BDYLIST card is not required and should not be used to specify a rigid boundary where structural points are not defined. Such a boundary is automatically implied by the omission of a BDYLIST.
6. If RHØ is 0.0, no boundary matrix terms will be generated to connect the GRIDB points to the fluid. This option is a convenience for structural plotting purposes. GRIDB points may be located on a fluid ring (RINGFL) only if the rings are included in a BDYLIST.

Input Data Card CAXIFi Fluid Element Connections

Description: Defines an axisymmetric fluid element which connects i = 2, i = 3, or i = 4 fluid points.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CAXIF2	EID	IDF1	IDF2			RHØ	B		
CAXIF2	11	23	25			.25E-03			
CAXIF3	EID	IDF1	IDF2	IDF3		RHØ	B		
CAXIF3	105	31	32	33			6.7E4		
CAXIF4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CAXIF4	524	421	425	424	422	.5-3	2.5+3		

Field	Contents
EID	Element identification number (Integer > 0)
IDFj	Identification numbers of connected GRIDF points, j = 1,2,...i (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or "blank")
B	Fluid bulk modulus (Real $\geq$ 0.0 or "blank")

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The element identification number (EID) must be unique with respect to all other fluid or structural elements.
3. If RHØ, or B are "blank" the corresponding values on the AXSLØT data card are used, in which case the default must not be blank (undefined).
4. Plot elements are generated for these elements. Because each plot element connects two points, one is generated for the CAXIF2 element, three are generated for the CAXIF3 element, and four plot elements are generated for the CAXIF4 element. In the last case the elements connect the pairs of points (1-2), (2-3), (3-4) and (4-1).
5. If B = 0.0, the fluid is considered to be incompressible.

Input Data Card CBAR Simple Beam Element Connection

Description: Defines a simple beam element (BAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CBAR	EID	PID	GA	GB	X1,G0	X2	X3	F	abc
CBAR	2	39	7	3	13			2	123
+bc	PA	PB	Z1A	Z2A	Z3A	Z1B	Z2B	Z3B	
+23		513							

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PBAR property card (Default is EID unless BARØR card has nonzero entry in field 3) (Integer > 0 or blank*)
GA,GB	Grid point identification numbers of connection points (Integer > 0; GA $\neq$ GB)
X1,X2,X3	Components of vector $\vec{v}$, at end A, (figure 1(a) on page 1.3-15) measured at end A, parallel to the components of the displacement coordinate system for GA, to determine (with the vector from end A to end B) the orientation of the element coordinate system for the bar element (Real, $X1^2 + X2^2 + X3^2 > 0$ or blank*, see below).
G0	Grid point identification number to optionally supply X1, X2, X3 (integer > 0 or blank*) (see below)
F	Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = blank*			
F = 1	X1	X2	X3
F = 2	G0	blank/0	blank/0

Field	Contents
PA,PB	Pin flags for bar ends A and B, respectively, that are used to insure that the bar cannot resist a force or moment corresponding to the pin flag at that respective end of the bar. (Up to 5 of the unique digits 1-6 anywhere in the field with no imbedded blanks; integer > 0) (These degree of freedom codes refer to the element forces and not global forces. The bar must have stiffness associated with the pin flag. For example, if pin flag 4 is specified, the bar must have a value for J, the torsional constant.)
Z1A,Z2A,Z3A Z1B,Z2B,Z3B	Components of offset vectors $\vec{w}_a$ and $\vec{w}_b$, respectively, (see figure 1(a), page 1.3-15) in displacement coordinate systems at points GA and GB, respectively. (Real or blank)

*See the BARØR card for default options for fields 3, 6, 7, 8 and 9.

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. For an explanation of bar element geometry, see Section 1.3.2.

3. Zero (0) must be used in fields 7 and 8 in order to override entries in these fields associated with F = 1 in field 9 on a BARØR card.

4. If there are no pin flags or offsets, the continuation card may be omitted.

Input Data Card CCØNEAX Axisymmetric Shell Element Connection

Description: Defines the connection of a conical shell element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CCØNEAX	ID	PID	RA	RB					
CCØNEAX	1	2	3	4					

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PCØNEAX card (Default is EID) (Integer > 0)
RA	Identification number of a RINGAX card (Integer > 0; RA ≠ RB)
RB	Identification number of a RINGAX card (Integer > 0; RA ≠ RB)

Remarks: 1. This card is allowed if and only if an AXIC card is also present.

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card CDAMP1 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP1	EID	PID	G1	C1	G2	C2			
CDAMP1	19	6	0		23	2			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP3 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. The two connection points, (G1, C1) and (G2, C2), must be distinct.

4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP2 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP2	EID	B	G1	C1	G2	C2			
CDAMP2	16	-2.98	32	1					

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The value of the scalar damper (Real)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP4 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This single card completely defines the element since no material or geometric properties are required.
4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP3 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP3	EID	PID	S1	S2	EID	PID	S1	S2	
CDAMP3	16	978	24	36	17	978	24	37	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar damper elements may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CDAMP4 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP4	EID	B	S1	S2	EID	B	S1	S2	
CDAMP4	16	-2.6	4	9	17	+8.6	3	7	

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The scalar damper value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. One or two scalar damper elements may be defined on a single card.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CDUMi Dummy Element Connection

Description: Defines a dummy element ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDUMi	EID	PID	G1	G2	G3	G4	-etc.-	GN	abc
CDUM2	114	108	2	5	6	8		11	ABC
+bc	A1	A2	-etc.-			AN			
+BC	2.4		3.E4	2		50			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PDUMi property card (Integer > 0)
G1...GN	Grid point identification numbers of connection points (Integer > 0, G1 $\neq$ G2 ... $\neq$ GN)
A1...AN	Additional entries (Real or Integer)

Remarks:

1. The user must code the associated element routines for matrix generation, stress recovery, etc., and perform a link edit to replace the dummy routines.
2. If no property card is required, field 3 may contain the material identification number.
3. Additional entries are defined in the user written element routines.

Input Data Card CELAS1 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS1	EID	PID	G1	C1	G2	C2			
CELAS1	2	6			8	1			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer > 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS3 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. The two connection points, (G1, C1) and (G2, C2), must be distinct.

4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CELAS2 Scalar Spring Property and Connection

Description: Defines a scalar spring element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS2	EID	K	G1	C1	G2	C2	GE	S	
CELAS2	28	6.2+3	32		19	4			

Field	Contents
EID	Unique element identification number (Integer > 0)
K	The value of the scalar spring (Real)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Components number ($6 \geq$ Integer ≥ 0)
GE	Damping coefficient (Real)
S	Stress coefficient (Real)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS4 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. This single card completely defines the element since no material or geometric properties are required.

4. The two connection points, (G1, C1) and (G2, C2), must be distinct.

5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CELAS3 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS3	EID	PID	S1	S2	EID	PID	S1	S2	
CELAS3	19	2	14	15	2	3	0	28	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar springs may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CELAS4 Scalar Spring Property and Connection

Description: Defines a scalar element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS4	EID	K	S1	S2	EID	K	S1	S2	
CELAS4	42	6.2-3	2		13	6.2-3	0	2	

Field	Contents
EID	Unique element identification number (Integer > 0)
K	The scalar spring value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 but not both may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. No damping coefficient is available with this form. (Assumed to be 0.0)
5. No stress coefficient is available with this form.
6. One or two scalar springs may be defined on a single card.
7. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CFLUIDi Fluid Element Connections

Description: Defines three types of fluid elements for axisymmetric fluid model.

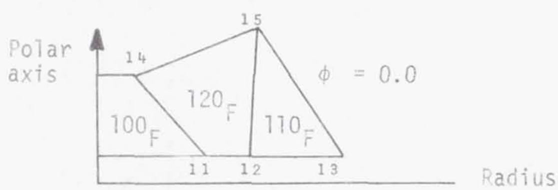
Format and Example:

1	2	3	4	5	6	7	8	9	10
CFLUID2	EID	IDF1	IDF2			RHØ	B		
CFLUID2	100	11	14			.025	0.0		
CFLUID3	EID	IDF1	IDF2	IDF3		RHØ	B		
CFLUID3	110	15	13	12		1.2			
CFLUID4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CFLUID4	120	11	15	12	14				

Field	Contents
EID	Element identification number (Integer, $0 < Id_c < 10^5$)
IDFi	Identification number of RINGFL card (Integer > 0; IDF1 ≠ IDF2 ≠ IDF3 ≠ IDF4)
RHØ	Mass density (Real > 0.0 or blank; If blank, the AXIF default value is used)
B	Bulk modulus, pressure per volume ratio (Real or blank. Default value on AXIF card is used if blank)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Element identification number must be unique with respect to all other fluid, scalar and structural elements.
3. The volume defined by IDFi is a body of revolution about the polar axis of the Fluid Coordinate System defined by AXIF. CFLUID2 defines a thick disk with IDF1 and IDF2 defining the outer corners as in the sketch.



4. All interior angles must be less than 180°.
5. The order of connected RINGFL points is arbitrary.
6. If the bulk modulus value is zero the fluid is assumed incompressible.

Input Data Card CHBDY   Heat Boundary Element

Description: Defines a boundary element for heat transfer analysis which is used for heat flux, thermal vector flux, convection and/or radiation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CHBDY	EID	PID	TYPE	G1	G2	G3	G4		
CHBDY	721	100	LINE	101	98				+BD721

+abc	GA1	GA2	GA3	GA4	V1	V2	V3		
+BD721	102	102			1.00	0.0	0.0		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Integer > 0)
TYPE	Type of area involved (must be one of "PØINT", "LINE", "REV", "AREA3", "AREA4" or "ELCYL")
G1,G2,G3,G4	Grid point identification numbers of primary connected points (Integer > 0 or blank)
GA1,GA2,GA3,GA4	Grid or scalar point identification numbers of associated ambient points (Integer > 0 or blank)
V1,V2,V3	Vector (in the basic coordinate system) used for element orientation (real or blank)

Remarks:

1. The continuation card is not required.

2. The six types have the following characteristics:

   a. The "PØINT" type has one primary grid point, requires a property card, and the normal vector {V1,V2,V3} must be given if thermal vector flux is to be used.

   b. The "LINE" type has two primary grid points, requires a property card, and the vector is required if thermal vector flux is to be used.

   c. The "REV" type has two primary grid points which must lie in the x-z plane of the basic coordinate system with x > 0. The defined area is a conical section with z as the axis of symmetry. A property card is required for convection, radiation, or thermal vector flux.

   d. The "AREA3" and "AREA4" types have three and four primary grid points, respectively. These points define a triangular or quadrilateral surface and must be ordered to go around the boundary. A property card is required for convection, radiation, or thermal vector flux.

   e. The "ELCYL" type (elliptic cylinder) has two connected primary grid points, it requires a property card, and if thermal vector flux is used, the vector must be nonzero.

CHBDY (Cont.)

3. A property card, PHBDY, is used to define the associated area factors, the emissivity, the absorbtivity, and the principal radii of the elliptic cylinder. The material coefficients used for convection and thermal capacity are referenced by the PHBDY card. See this card description for details.

4. The associated points, GA1, GA2, etc., may be either grid or scalar points, and are used to define the ambient temperature for a convection field. These points correspond to the primary points G1, G2, etc., and the number of them depends on the TYPE option, but they need not be unique. Their values may be set in statics with an SPC card, or they may be connected to other elements. If any field is blank, the ambient temperature associated with that grid point is assumed to be zero.

5. Heat flux may be applied to this element with QBDY1 or QBDY2 cards.

6. Thermal vector flux from a directional source may be applied to this element with a QVECT card. See Figure 1 on page 1.8-7 for the definition of the normal vector for each element type.

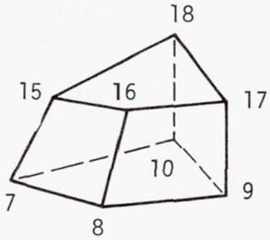
Input Data Card <u>CHEXAi</u> Hexahedron Element Connection

Description: Defines two types of hexahedron elements (3 dimensional solid with 8 vertices and 6 quadrilateral faces, HEXAi) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CHEXAi	EID	MID	G1	G2	G3	G4	G5	G6	abc
CHEXA2	15	2	7	8	9	10	15	16	ABC
+bc	G7	G8							
+BC	17	18							

Field	Contents
CHEXAi	CHEXA1 or CHEXA2 (see Remark 7)
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,...,G8	Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ ... ≠ G8)



Remarks:

1. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.

2. The order at the grid points is: G1, G2, G3, G4 in order around one quadrilateral face. G5, G6, G7, G8 are in order in the same direction around the opposite quadrilateral, with G1 and G5 along the same edge.

3. The quadrilateral faces must be nearly planar.

4. There is no nonstructural mass.

5. For structural problems, material must be defined by MAT1 card.

6. Stresses are given in the basic coordinate system.

7. CHEXA1 represents the element as 5 tetrahedra, CHEXA2 represents the element as 10 overlapping tetrahedra.

8. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

NASTRAN DATA DECK

Input Data Card CMASS1 Scalar Mass Connection

Description: Defines a scalar mass element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS1	EID	PID	G1	C1	G2	C2			
CMASS1	32	6	2	1	2	3			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PMASS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS3 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. The two connection points, (G1, C1) and (G2, C2), must be distinct.

4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CMASS2 Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS2	EID	M	G1	C1	G2	C2			
CMASS2	32	9.25	6	1	7				

Field	Contents
EID	Unique element identification number (Integer > 0)
M	The value of the scalar mass (Real)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS4 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. This card completely defines the element since no material or geometric properties are required.

4. The two connection points, (G1, C1) and (G2, C2), must be distinct.

5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CMASS3 Scalar Mass Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS3	EID	PID	S1	S2	EID	PID	S1	S2	
CMASS3	13	42	62	1					

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PMASS property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar masses may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card CMASS4 Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS4	EID	M	S1	S2	EID	M	S1	S2	
CMASS4	23	14.92	6	23	2	-16.3	0	29	

Field	Contents
EID	Unique element identification number (Integer > 0)
M	The scalar mass value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. One or two scalar masses may be defined on a single card.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card C∅NM1 Concentrated Mass Element Connection

Description: Defines a 6x6 symmetric mass matrix at a geometric grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
C∅NM1	EID	G	CID	M11	M21	M22	M31	M32	abc
C∅NM1	2	22	2	2.9		6.3			+1
+bc	M33	M41	M42	M43	M44	M51	M52	M53	def
+1	4.8				28.6				+2
+ef	M54	M55	M61	M62	M63	M64	M65	M66	
+2		28.6						28.6	

Field	Contents
EID	Unique element identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number for the mass matrix (Integer ≥ 0)
Mij	Mass matrix values (Real)

Remarks: 1. For a less general means of defining concentrated mass at grid points, see C∅NM2.

2. Element identification numbers must be unique with respect to all other element identification numbers.

BULK DATA DECK

Input Data Card CØNM2 Concentrated Mass Element Connection

Description: Defines a concentrated mass at a grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNM2	EID	G	CID	M	X1	X2	X3		abc
CØNM2	2	15	6	49.7					123

+bc	I11	I21	I22	I31	I32	I33			
+23	16.2		16.2			7.8			

Field	Contents
EID	Element identification number (Integer > 0)
G	Grid point identification number (Integer >0)
CID	Coordinate system identification number (Integer $\geq$ 0)
M	Mass Value (Real)
X1,X2,X3	Offset distances for the mass in the coordinate system defined in field 4 (Real)
Iij	Mass moments of inertia measured at the mass c.g. in coordinate system defined by field 4 (Real)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. For a more general means of defining concentrated mass at grid points, see CØNM1.
3. The continuation card may be omitted.

Input Data Card CØNRØD   Rod Element Property and Connection

Description: Defines a rod element of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNRØD	EID	G1	G2	MID	A	J	C	NSM	
CØNRØD	2	16	17	23	2.69				

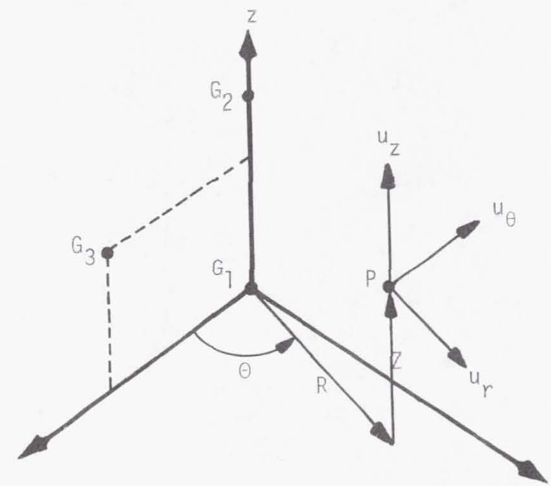
Field	Contents
EID	Unique element identification number (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient for torsional stress determination (Real)
NSM	Nonstructural mass per unit length (Real)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. For structural problems, CØNRØD cards may only reference MAT1 material cards.
3. For heat transfer problems, CØNRØD cards may only reference MAT4 or MAT5 material cards.

Input Data Card CØRD1C   Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

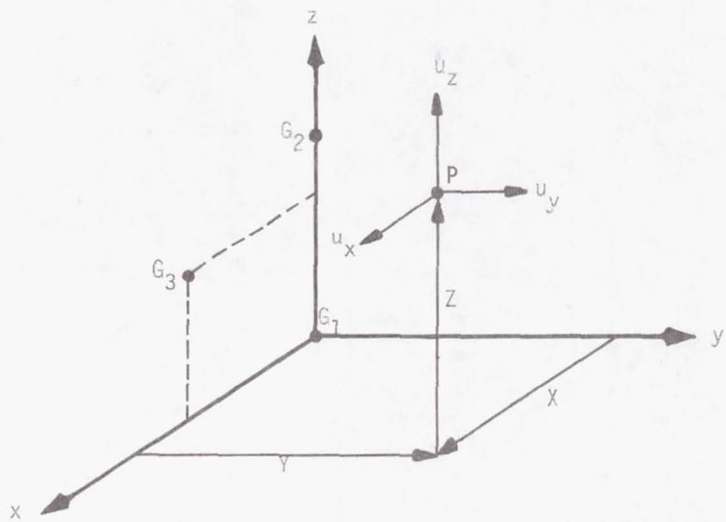
1	2	3	4	5	6	7	8	9	10
CØRD1C	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1C	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 $\neq$ G2 $\neq$ G3)

Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
2. The three points G1, G2, G3 must be noncollinear.
3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Z) where Θ is measured in degrees.
4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_z).
5. Points on the z-axis may not have their displacement directions defined in this coordinate system since an ambiguity results.
6. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD1R   Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the x-z plane.



Format and Example:

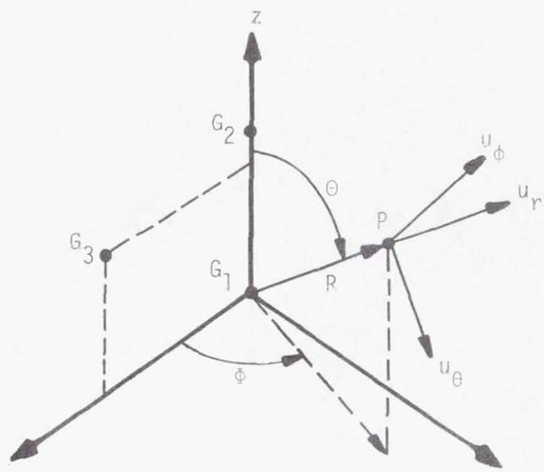
1	2	3	4	5	6	7	8	9	10
CØRD1R	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1R	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 ≠ G2 ≠ G3)

Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
2. The three points G1, G2, G3 must be noncollinear.
3. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
4. The displacement coordinate directions at P are shown above by (u_x, u_y, u_z).
5. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD1S   Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD1S	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1S	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 ≠ G2 ≠ G3)

Remarks:

1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.

2. The three points G1, G2, G3 must be noncollinear.

3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Φ) where Θ and Φ are measured in degrees.

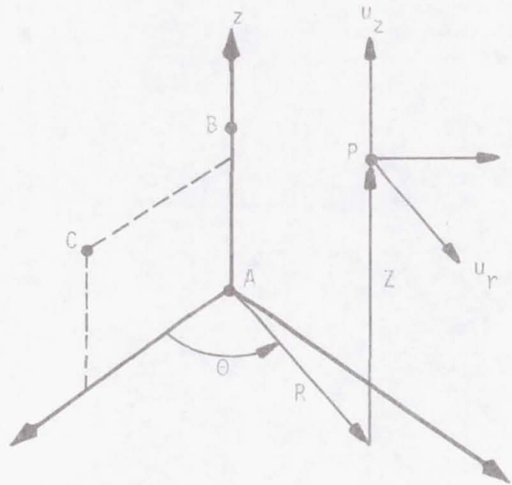
4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_ϕ).

5. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.

6. One or two coordinate systems may be defined on a single card.

Input Data Card CØRD2C Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2C	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2C	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

(continued)

CØRD2C (cont.)

Remarks: 1. Continuation card must be present.

2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and noncollinear. Noncollinearity is checked by the geometry processor.

3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.

4. An RID of zero references the basic coordinate system.

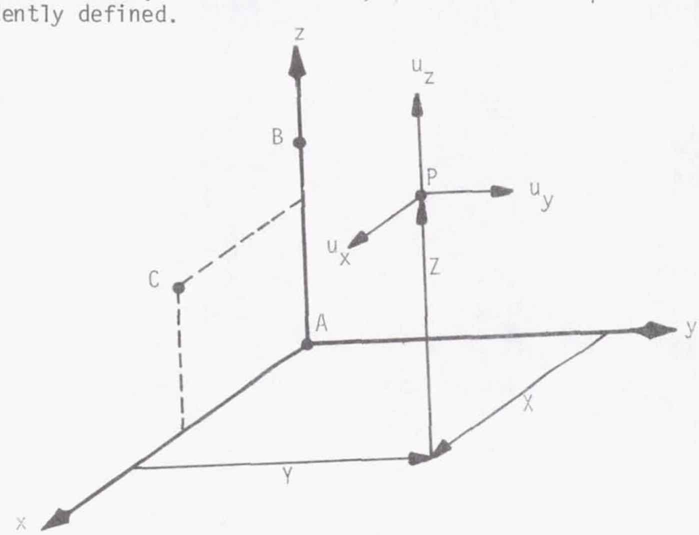
5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Z) where Θ is measured in degrees.

6. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_z).

7. Points on the z-axis may not have their displacement direction defined in this coordinate system since an ambiguity results.

Input Data Card CØRD2R   Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third point defines a vector which, with the z-axis, defines the x-z plane. The reference coordinate must be independently defined.



Format and Example:

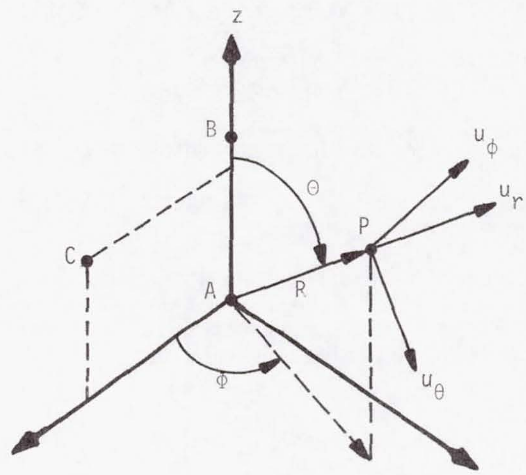
1	2	3	4	5	6	7	8	9	10
CØRD2R	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2R	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

Remarks:
1. Continuation card must be present.
2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and noncollinear. Noncollinearity is checked by the geometry processor.
3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
4. An RID of zero references the basic coordinate system.
5. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
6. The displacement coordinate directions at P are shown by (u_x, u_y, u_z).

Input Data Card CØRD2S   Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2S	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2S	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field	Contents
CID	Coordinate system identification number (Integer > 0)
RID	Reference to a coordinate system which is defined independently of new coordinate system (Integer $\geq$ 0 or blank)
A1,A2,A3 B1,B2,B3 C1,C2,C3	Coordinates of three points in coordinate system defined in field 3 (Real)

(Continued)

CØRD2S (cont.)

Remarks: 1. Continuation card must be present.

2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and non-collinear. Noncollinearity is checked by the geometry processor.

3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.

4. An RID of zero references the basic coordinate system.

5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ, Φ) where Θ and Φ are measured in degrees.

6. The displacement coordinate directions at P are shown above by (u_r, u_θ, u_ϕ).

7. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.

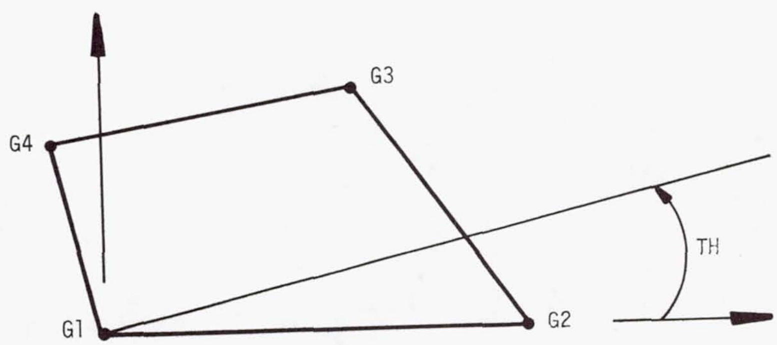
Input Data Card CQDMEM Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM) of the structural model consisting of four overlapping TRMEM elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM	EID	PID	G1	G2	G3	G4	TH		
CQDMEM	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180°.

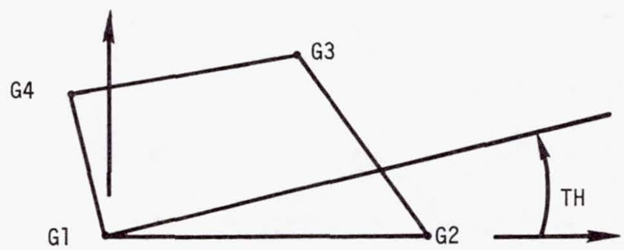
Input Data Card CQDMEM1 Isoparametric Quadrilateral Element Connection

Description: Defines an isoparametric quadrilateral membrane element (QDMEM1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM1	EID	PID	G1	G2	G3	G4	TH		
CQDMEM1	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM1 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0); G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180 degrees.

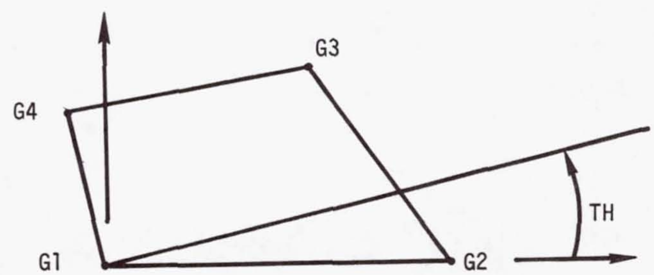
Input Data Card CQDMEM2 Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM2) of the structural model consisting of four nonoverlapping TRMEM elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM2	EID	PID	G1	G2	G3	G4	TH		
CQDMEM2	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM2 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180 degrees.

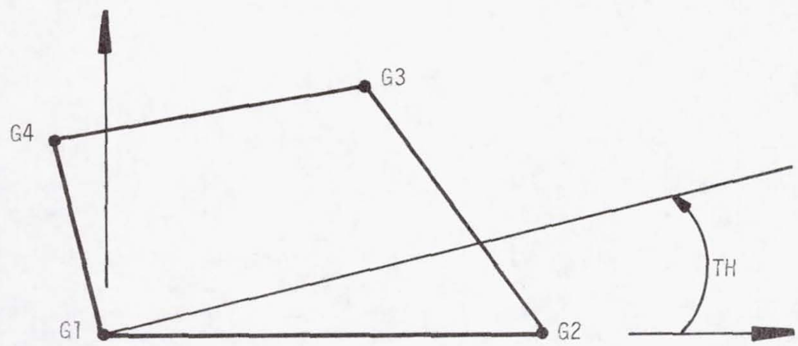
Input Data Card CQDPLT Quadrilateral Element Connection

Description: Defines a quadrilateral bending element (QDPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDPLT	EID	PID	G1	G2	G3	G4	TH		
CQDPLT	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDPLT property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180°.
4. No structural mass is generated by this element.

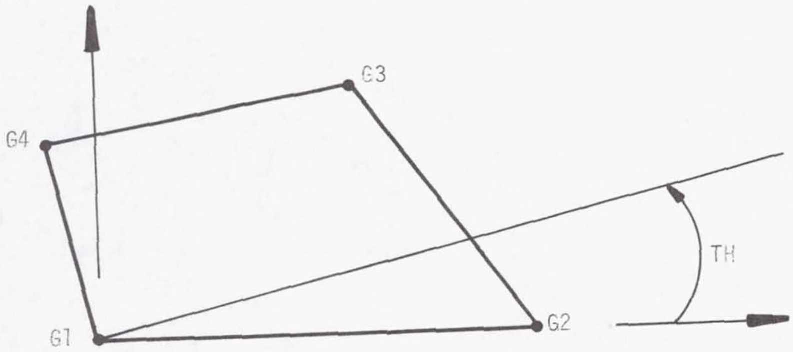
Input Data Card CQUAD1   Quadrilateral Element Connection

Description: Defines a quadrilateral membrane and bending element (QUAD1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD1	EID	PID	G1	G2	G3	G4	TH		
CQUAD1	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQUAD1 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

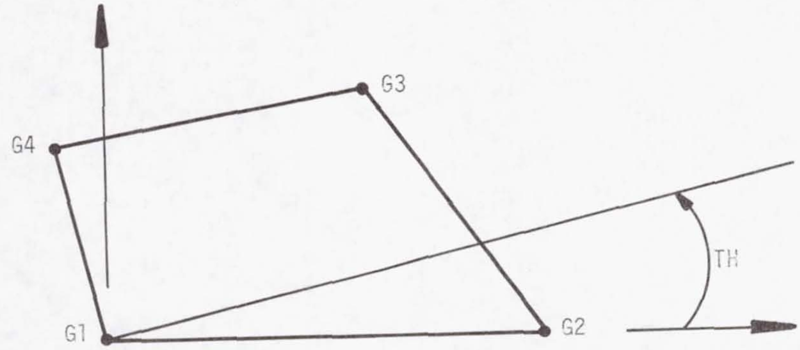
Input Data Card CQUAD2 Quadrilateral Element Connection

Description: Defines a homogeneous quadrilateral membrane and bending element (QUAD2) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD2	EID	PID	G1	G2	G3	G4	TH		
CQUAD2	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQUAD2 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

Input Data Card CRØD Rod Element Connection

Description: Defines a tension-compression-torsion element (RØD) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRØD	EID	PID	G1	G2	EID	PID	G1	G2	
CRØD	12	13	21	23	3	12	24	5	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PRØD property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. See CØNRØD for alternative method of rod definition.
3. One or two RØD elements may be defined on a single card.

Input Data Card CSHEAR Shear Panel Element Connection

Description: Defines a shear panel element (SHEAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CSHEAR	EID	PID	G1	G2	G3	G4			
CSHEAR	3	6	1	5	3	7			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PSHEAR property card (Default is EID) (Integer > 0)
G1, G2, G3, G4	Grid point identification numbers of connection points (Integer > 0; $G1 \neq G2 \neq G3 \neq G4$)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180°.

Input Data Card CSLOTi Slot Element Connections

Description: Defines an element connecting i = 3 or i = 4 points which solves the wave equation in two dimensions. Used in the acoustic cavity analysis for the definition of evenly spaced radial slots.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CSLØT3	EID	IDS1	IDS2	IDS3		RHØ	B	M	
CSLØT3	100	1	3	2		3.E-3		6	

1	2	3	4	5	6	7	8	9	10
CSLØT4	EID	IDS1	IDS2	IDS3	IDS4	RHØ	B	M	
CSLØT4	101	1	3	2	4		6.2+4	3	

Field	Contents
EID	Element identification number (Integer > 0)
IDSj	Identification number of connected GRIDS points, j = 1,2,...J (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or "blank")
B	Fluid bulk modulus (Real ≥ 0.0 or blank)
M	Number of slots in circumferential direction (Integer ≥ 0, or "blank")

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The element identification number (IDF) must be unique with respect to all other fluid or structural elements.
3. If RHØ, B, or M are blank, the corresponding values on the AXSLØT data card are used, in which case the default value must not be blank (undefined).
4. Plot elements connecting two points at a time are generated for these elements. The CSLØT3 element generates 3 plot elements. The CSLØT4 element generates four plot elements, connecting points 1-2, 2-3, 3-4, and 4-1.
5. If B = 0.0, the slot is considered to be an incompressible fluid.
6. If M = 0 no matrices for CSLØTi elements are generated.

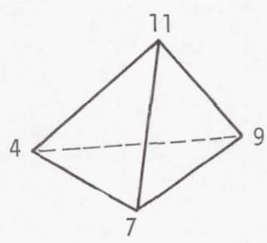
Input Data Card CTETRA Tetrahedron Element Connection

Description: Defines a tetrahedron element (3 dimensional solid with 4 vertices and 4 triangular faces, TETRA) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTETRA	EID	MID	G1	G2	G3	G4			
CTETRA	15	2	4	7	9	11			

Field	Contents
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ G3 ≠ G4)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. There is no nonstructural mass.
3. For structural problems, material must be defined by MAT1 card.
4. Output stresses are given in basic coordinate system.
5. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

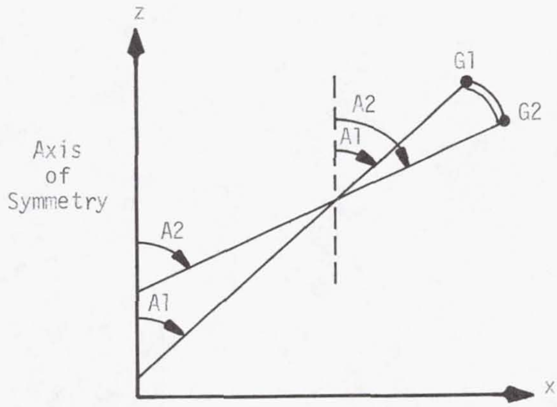
Input Data Card CTØRDRG Toroidal Ring Element Connection

Description: Defines an axisymmetric toroidal cross-section ring element (TØRDRG) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTØRDRG	EID	PID	G1	G2	A1	A2			
CTØRDRG	25	2	47	48	30.0	60.0			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Default is EID) (Integer > 0)
G1, G2	Grid Point identification numbers of connection points (Integer > 0; G1 $\neq$ G2)
A1	Angle of curvature at grid point 1 in degrees (Real; $0° \leq A1 \leq 180°$)
A2	Angle of curvature at grid point 2 in degrees (Real; $0° \leq A2 \leq 180°$)



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 and G2 must lie in the x-z plane of the basic coordinate system and to the right of the axis of symmetry (the z-axis).

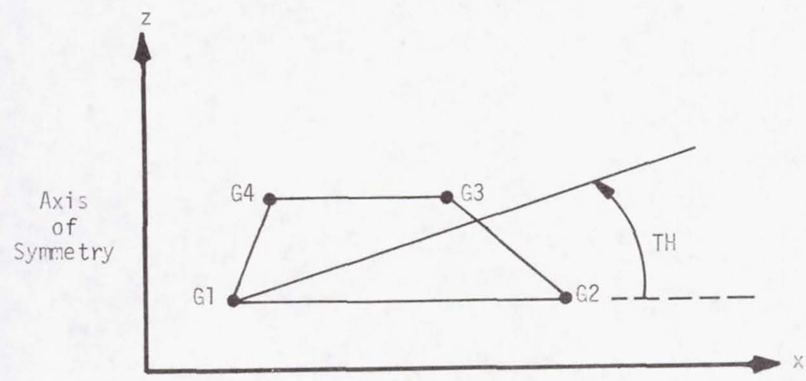
Input Data Card CTRAPRG   Trapezoidal Ring Element Connection

Description: Defines an axisymmetric trapezoidal cross-section ring element (TRAPRG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRAPRG	EID	G1	G2	G3	G4	TH	MID		
CTRAPRG	72	13	14	15	16	29.2	13		

Field	Contents
EID	Element identification number (Integer > 0)
G1,G2,G3,G4	Grid point identification number of connection points (Integers > 0; G1 ≠ G2 ≠ G3 ≠ G4)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.
MID	Material property identification number (Integer > 0)



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The four grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).

3. Grid points G1, G2, G3 and G4 must be ordered counterclockwise around the perimeter of the element as in the above sketch.

4. The line connecting grid points G1 and G2 and the line connecting grid points G3 and G4 must both be parallel to the x-axis.

5. All interior angles must be less than 180°.

6. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.

7. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

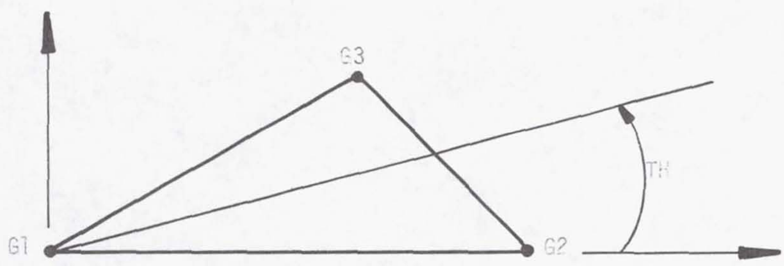
Input Data Card CTRBSC   Triangular Element Connection

Description: Defines a basic triangular bending element (TRBSC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRBSC	EID	PID	G1	G2	G3	TH			
CTRBSC	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRBSC property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

3. No structural mass is generated by this element.

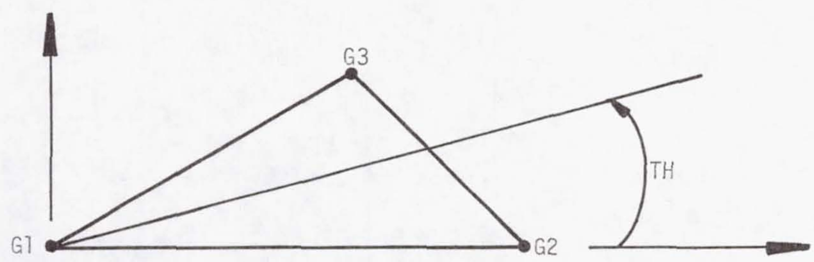
Input Data Card CTRIA1 Triangular Element Connection

Description: Defines a triangular membrane and bending element (TRIA1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIA1	EID	PID	G1	G2	G3	TH			
CTRIA1	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA1 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

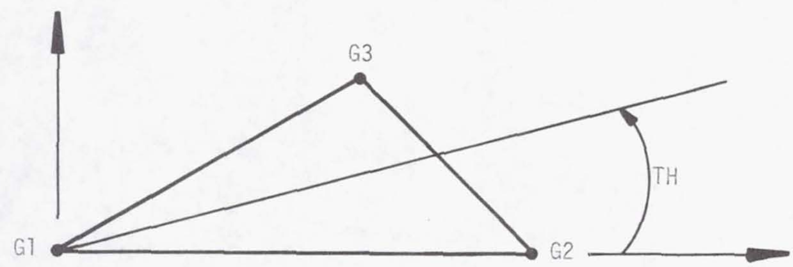
Input Data Card CTRIA2 Triangular Element Connection

Description: Defines a triangular membrane and bending element (TRIA2) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIA2	EID	PID	G1	G2	G3	TH			
CTRIA2	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA2 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; $G1 \neq G2 \neq G3$)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

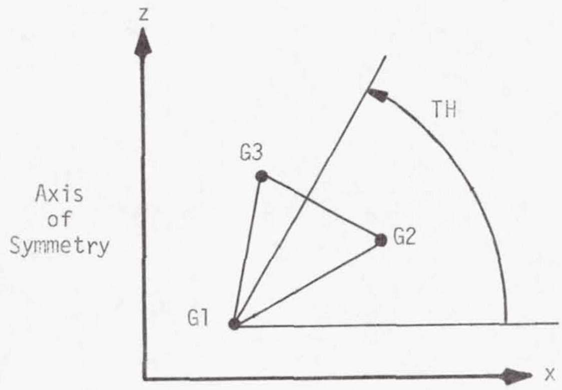
Input Data Card CTRIARG Triangular Ring Element Connection

Description: Defines an Axisymmetric triangular cross section ring element (TRIARG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIARG	EID	G1	G2	G3	TH	MID			
CTRIARG	16	12	13	14	29.2	17			

Field	Contents
EID	Element identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers of connection points (Integers > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for the TH.
MID	Material identification number (Integer > 0)



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).

3. Grid points G1, G2 and G3 must be ordered counterclockwise around the perimeter or the element as in the above sketch.

4. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.

5. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

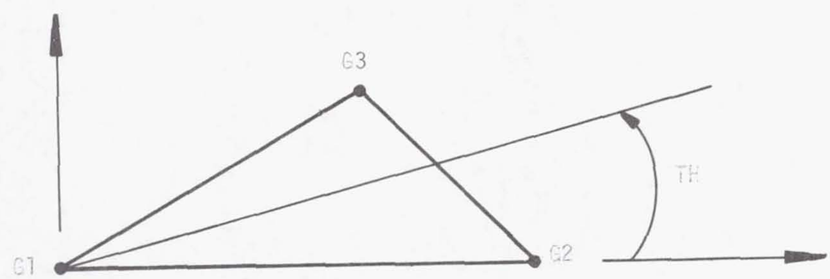
Input Data Card CTRMEM Triangular Element Connection

Description: Defines a triangular membrane element (TRMEM) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRMEM	EID	PID	G1	G2	G3	TH			
CTRMEM	16	2	12	1	3	16.3			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRMEM property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; $G1 \neq G2 \neq G3$)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

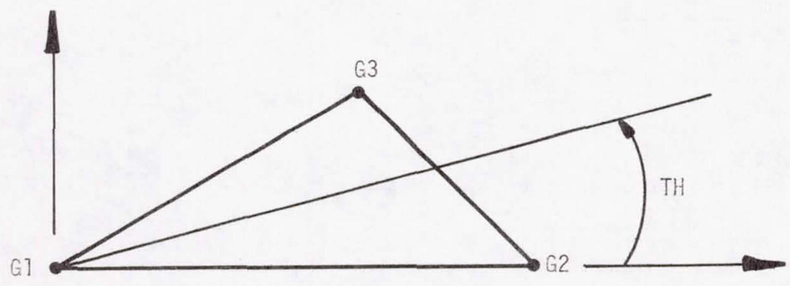
Input Data Card CTRPLT Triangular Element Connection

Description: Defines a triangular bending element (TRPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRPLT	EID	PID	G1	G2	G3	TH			
CTRPLT	16	2	12	1	3	16.2			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRPLT property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Interior angles must be less than 180°.

3. No structural mass is generated by this element.

Input Data Card CTUBE Tube Element Connection

Description: Defines a tension-compression-torsion element (TUBE) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTUBE	EID	PID	G1	G2	EID	PID	G1	G2	
CTUBE	12	13	21	23	3	12	24	5	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTUBE property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two TUBE elements may be defined on a single card.

Input Data Card CTWIST   Twist Panel Element Connection

Description: Defines a twist panel element (TWIST) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTWIST	EID	PID	G1	G2	G3	G4			
CTWIST	2	6	1	5	3	7			

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PTWIST property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4)

Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
3. All interior angles must be less than 180°.

Input Data Card CVISC Viscous Damper Connection

Description: Defines a viscous damper element (VISC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CVISC	EID	PID	G1	G2	EID	PID	G1	G2	
CVISC	21	6327	29	31	22	6527	35	33	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of PVISC property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two VISC elements may be defined on a single card.

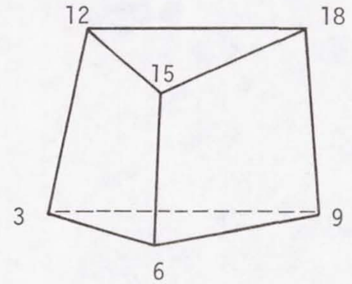
Input Data Card CWEDGE Wedge Element Connection

Description: Defines a wedge element (3 dimensional solid, with three quadrilateral faces and two opposing triangular faces, WEDGE) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CWEDGE	EID	MID	G1	G2	G3	G4	G5	G6	
CWEDGE	15	2	3	6	9	12	15	18	

Field	Contents
EID	Element identification number (Integer > 0)
MID	Material identification number (Integer > 0)
G1,...,G6	Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ ... ≠ G6)



Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. The order of the grid points is: G1, G2, G3 on one triangular face, G4, G5, G6 at the other triangular face. G1, G4 on a common edge, G2, G5 on a common edge.
3. The quadrilateral faces must be nearly planar.
4. There is no nonstructural mass.
5. For structural problems, material must be defined by MAT1 card.
6. Output stresses are given in the basic coordinate system.
7. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

Input Data Card DAREA Dynamic Load Scale Factor

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1, and TLØAD2 data cards and defines the point where the dynamic load is to be applied with the scale (area) factor A.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DAREA	SID	P	C	A	P	C	A	X	
DAREA	3	6	2	8.2	15	1	10.1		

Field	Contents
SID	Identification number of DAREA set (Integer > 0)
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point; blank or 0 for scalar point)
A	Scale (area) factor A for the designated coordinate (Real)

Remarks: One or two dynamic load time delays may be defined on a single card.

Input Data Card DEFØRM Element Deformation

Description: Defines enforced axial deformation for one-dimensional elements for use in statics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DEFØRM	SID	EID	D	EID	D	EID	D		
DEFØRM	1	535	.05	536	-.10				

Field	Contents
SID	Deformation set identification number (Integer > 0)
EID	Element number (Integer > 0)
D	Deformation (+ = elongation) (Real)

Remarks:

1. The referenced element must be one-dimensional (i.e., a RØD (including CØNRØD), TUBE or BAR).
2. Deformation sets must be selected in the Case Control Deck (DEFØRM=SID) to be used by NASTRAN.
3. From one to three enforced element deformations may be defined on a single card.

Input Data Card DELAY Dynamic Load Time Delay

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1 and TLØAD2 data cards and defines the time delay term τ in the equations of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DELAY	SID	P	C	T	P	C	T		
DELAY	5	21	6	4.25	7	6	8.1		

Field	Contents
SID	Identification number of DELAY set (Integer > 0)
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point, blank or 0 for scalar point)
T	Time delay τ for designated coordinate (Real)

Remarks: One or two dynamic load time delays may be defined on a single card.

Input Data Card DLØAD Dynamic Load Combination (Superposition)

Description: Defines a dynamic loading condition for frequency response or transient response problems as a linear combination of load sets defined via RLØAD1 or RLØAD2 cards (for frequency response) or TLØAD1 or TLØAD2 cards (for transient response).

Format and Example:

1	2	3	4	5	6	7	8	9	10
DLØAD	SID	S	S1	L1	S2	L2	S3	L3	+abc
DLØAD	17	1.0	2.0	6	-2.0	7	2.0	8	+A
+abc	S4	L4		-etc.-					
+A	-2.0	9							

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale Factor (Real)
Si	Scale Factors (Real)
Li	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks:
1. The load vector being defined by this card is given by

$$\{P\} = S \sum_i S_i \{P_i\} .$$

2. The Li must be unique.
3. SID must be unique from all Li.
4. Nonlinear transient loads may not be included; they are selected separately in the Case Control Deck.
5. Linear load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
6. A DLØAD card may not reference a set identification number defined by another DLØAD card.
7. TLØAD1 and TLØAD2 loads may be combined only thru the use of the DLØAD card.
8. RLØAD1 and RLØAD2 loads may be combined only thru the use of the DLØAD card.
9. SID must be unique for all TLØAD1, TLØAD2, RLØAD1, and RLØAD2 cards.

Input Data Card <u>DMI</u> Direct Matrix Input

<u>Description</u>: Used to define matrix data blocks directly. Generates a matrix of the form

$$[A] = \begin{bmatrix} A_{11} & A_{12} \cdots\cdots\cdots & A_{1n} \\ A_{21} & A_{22} \cdots\cdots\cdots & A_{2n} \\ \vdots & \vdots & \vdots \\ A_{m1} & \cdots\cdots\cdots\cdots & A_{mn} \end{bmatrix}$$

where the elements A_{ij} may be real or complex single-precision numbers.

<u>Formats and Example</u>: (The first logical card is a header card.)

1	2	3	4	5	6	7	8	9	10
DMI	NAME	"0"	FØRM	TIN	TØUT		M	N	
DMI	QQQ	0	2	3	3		4	2	

1	2	3	4	5	6	7	8	9	10
DMI	NAME	J	I1	A(I1,J)	A(I1+1,J)		etc.	I2	+abc
DMI	QQQ	1	1	1.0	2.0	3.0	4.0	3	+1
+abc	A(I2,J)		etc.						
+1	5.0	6.0							

1	2	3	4	5	6	7	8	9	10
DMI	QQQ	2	2	6.0	7.0	4	8.0	9.0	

(etc. for each nonnull column)

<u>Field</u>	<u>Contents</u>
NAME	Any NASTRAN BCD value (1-8 alphnumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
FØRM	1 Square matrix (not symmetric) 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 2 Real, double-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element) 4 Complex, double-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
M	Number of rows in A (Integer > 0)
N	Number of columns in A (Integer > 0)
J	Column number of A (Integer > 0)
I1,I2,etc.	Row number of A (Integer > 0)
A(Ix,J)	Element of A (See TIN) (Real)

(Continued)

DMI (cont.)

Remarks: 1. The user must write a DMAP (or make alterations to a rigid format) in order to use the DMI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply. In the example shown above, the data block QQQ is defined to be the complex, single-precision rectangular 4x2 matrix

$$[QQQ] = \begin{bmatrix} (1.0,\ 2.0) & (0.0,\ 0.0) \\ (3.0,\ 4.0) & (6.0,\ 7.0) \\ (5.0,\ 6.0) & (0.0,\ 0.0) \\ (0.0,\ 0.0) & (8.0,\ 9.0) \end{bmatrix}$$

The DMAP data block NAME (QQQ in the example) will appear in the initial FIAT and the data block will initially appear on the Data Pool File (PØØL).

2. A limit to the number of DMI's which may be defined is set by the size of the Data Pool Dictionary. The total number of DMI's may not exceed this size.

3. There are a number of reserved words which may not be used for DMI names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, GEØM1, GEØM2, GEØM3, GEØM4 GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH1 thru SCRATCH9.

4. Field 3 of the header card must contain an integer 0.

5. For symmetric matrices, the entire matrix must be input.

6. Only nonzero terms need be entered.

7. A blank field on this card is not equivalent to a zero. If zero input is desired, the appropriate type zero must be punched (i.e., 0.0 or 0.0D0).

8. Complex input must have both the real and imaginary parts punched if either part is nonzero.

Input Data Card DMIAX Direct Axisymmetric Matrix Input

Description: Defines axisymmetric (fluid or structure) related direct input matrix terms.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	"0"	IFØ	TIN	TØUT				
DMIAX	B2PP	0	1	3	4				
DMIAX	NAME	GJ	CJ	NJ					+abc
DMIAX	B2PP	32							+BG27
+abc	GI	CI	NI	X_{ij}	Y_{ij}				+def
+BG27	1027	3		4.35+6	2.27+3				

-etc. for each column and row containing nonzero terms-

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix; 2 General rectangular matrix; 6 Symmetric matrix — Identification of Matrix Form
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double precision 4 Complex, double-precision
GJ, GI	Grid, scalar, RINGFL fluid point, PRESPT pressure point, FREEPT free surface displacement, or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ or GI grid point ($0 \leq$ Integer ≤ 6; Blank or zero if GJ or GI is a scalar, fluid, or extra point)
NJ, NI	Harmonic number of RINGFL point. Must be blank if a point type other than RINGFL is used. Negative number implies the "sine" series, positive implies the "cosine" series. (Integer)
X_{ij}, Y_{ij}	Real and Imaginary parts of matrix element; row (GI, CI, NI) column (GJ,CJ,NJ)

(Continued)

DMIAX (Cont.)

Remarks: 1. This card is allowed only if an AXIF card is also present.

2. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$ respectively.

3. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of two or more physical cards is needed for each nonnull column of the matrix.

4. If TIN = 1, Y_{ij} must be blank.

5. Field 3 of the header card must contain an integer 0.

6. For symmetric matrices, the entire matrix must be input.

7. Only nonzero terms need be entered.

Input Data Card DMIG Direct Matrix Input at Grid Points

Description: Defines structure-related direct input matrices.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIG	NAME	"0"	IFØ	TIN	TØUT				
DMIG	STIF	0	1	3	4				

1	2	3	4	5	6	7	8	9	10
DMIG	NAME	GJ	CJ		GI	CI	X_{ij}	Y_{ij}	Xabc
DMIG	STIF	27	1		2	3	3.+5	3.+3	EKG1
+abc	GI	CI	X_{ij}	Y_{ij}	GI	CI	X_{ij}	Y_{ij}	Xcef
+KG1	2	4	2.5+10	0.	50		1.0	0.	

etc. for each column containing nonzero terms

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
GJ, GI	Grid or scalar or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ a grid point ($0 < CJ \leq 6$); blank or zero for GJ a scalar or extra point
X_{ij}, Y_{ij}	Real and imaginary parts of matrix element

Remarks:

1. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$, respectively.
2. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of one or more physical cards is needed for each nonnull column of the matrix.
3. If TIN = 1, Y_{ij} must be blank.
4. Field 3 of the header card must contain an integer 0.
5. For symmetric matrices, the entire matrix must be input.
6. Only nonzero terms need be entered.
7. The matrix names must be unique among all DMIG's.

Input Data Card DMIAX Direct Axisymmetric Matrix Input

Description: Defines axisymmetric (fluid or structure) related direct input matrix terms.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	"0"	IFØ	TIN	TØUT				
DMIAX	B2PP	0	1	3	4				

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	GJ	CJ	NJ					+abc
DMIAX	B2PP	32							+BG27

1	2	3	4	5	6	7	8	9	10
+abc	GI	CI	NI	X_{ij}	Y_{ij}				+def
+BG27	1027	3		4.35+6	2.27+3				

-etc. for each column and row containing nonzero terms-

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix } Identification of Matrix Form
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double precision 4 Complex, double-precision
GJ, GI	Grid, scalar, RINGFL fluid point, PRESPT pressure point, FREEPT free surface displacement, or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ or GI grid point (0 ≤ Integer ≤ 6; Blank or zero if GJ or GI is a scalar, fluid, or extra point)
NJ, NI	Harmonic number of RINGFL point. Must be blank if a point type other than RINGFL is used. Negative number implies the "sine" series, positive implies the "cosine" series. (Integer)
X_{ij}, Y_{ij}	Real and Imaginary parts of matrix element; row (GI, CI, NI) column (GJ,CJ,NJ)

(Continued)

DMIAX (Cont.)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$ respectively.
3. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of two or more physical cards is needed for each nonnull column of the matrix.
4. If TIN = 1, Y_{ij} must be blank.
5. Field 3 of the header card must contain an integer 0.
6. For symmetric matrices, the entire matrix must be input.
7. Only nonzero terms need be entered.

Input Data Card DPHASE   Dynamic Load Phase Lead

Description: This card is used in conjunction with the RLØAD1 and RLØAD2 data cards to define the phase lead term θ in the equation of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DPHASE	SID	P	C	TH	P	C	TH		
DPHASE	4	21	6	2.1	8	6	7.2		

Field	Contents
SID	Identification number of DPHASE set (Integer > 0)
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point, 0 or blank for scalar point)
TH	Phase lead θ (in degrees) for designated coordinate (Real)

Remarks: One or two dynamic load phase lead terms may be defined on a single card.

Input Data Card DSFACT Differential Stiffness Factors

Description: Used to define scale factors for applied loads and stiffness matrices in a Differential Stiffness Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DSFACT	SID	B1	B2	B3	B4	B5	B6	B7	abc
DSFACT	97	-1.0	-2.0	-4.0					

+bc	B8	B9	-etc.-						

-etc.-

Field	Contents
SID	Set identification number (Unique Integer > 0)
Bi	Scale factor (Real)

Remarks:
1. Load sets must be selected in the Case Control Deck (DSCØ=SID) to be used by NASTRAN.
2. All fields following the last entry must be blank.
3. An error is detected if any continuation cards follow the last entry.

Input Data Card DTI Direct Table Input

Description: Used to define table data blocks directly.

Format and Example: (The first logical card is a header card)

1	2	3	4	5	6	7	8	9	10
DTI	NAME	"0"	T1	T2	T3	T4	T5	T6	+00
DTI	XXX	0	3	4	4096	32768	1	0	

+00	V	V		-etc.-	ENDREC				+01

-etc.-

DTI	NAME	IREC	V	V	V	V	V	V	+11
DTI	XXX	1	2.0	-6	ABC	6.0D0	-1	2	+11

+11	V	V	V	V	-etc.-		ENDREC		+12
+11	4	-6.2	2.9	1	DEF	-1	ENDREC		

-etc.-

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphanumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
Ti	Trailer values (65535 $\geq$ Integer $\geq$ 0)
IREC	Record Number (sequential integer beginning with 1)
V	Value (blank, integer, real, BCD (except "ENDREC"), double precision)
ENDREC	The BCD value ENDREC which flags the end of the string of values that constitute logical record IREC

Remarks:

1. Records may be made as long as desired via continuation cards.

2. Values may be of any type (blank, integer, real, BCD, double precision) with the exception that a BCD value may not be "ENDREC".

3. All fields following ENDREC must be blank.

4. The user must write a DMAP (or make alterations to a rigid format) in order to use the DTI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply.

5. The DMAP data block NAME (XXX in the example) will appear in the initial FIAT and the data block will initially appear on the PØØL.

6. If trailer is not specified, T1 = number of records, T2 thru T6 = 0.

7. In addition to the header card, there must be one logical card for each record in the table.

Input Data Card EIGB Buckling Analysis Data

Description: Defines data needed to perform buckling analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGB	SID	METHØD	L1	L2	NEP	NDP	NDN	E	+abc
EIGB	13	DET	0.1	2.5	2	1	1	0.0	ABC
+abc	NØRM	G	C						
+BC	MAX								

Field	Contents
SID	Set identification number (Unique integer > 0)
METHØD	Method of eigenvalue extraction, one of the BCD values "INV", "DET", "UINV", or "UDET"
	INV - Inverse power method, symmetric matrix operations
	DET - Determinant method, symmetric matrix operations
	UINV - Inverse power method, unsymmetric matrix operations
	UDET - Determinant method, unsymmetric matrix operations
L1,L2	Eigenvalue range of interest (Real; L1 < L2 > 0.0)
NEP	Estimate of number of roots in positive range (Integer > 0)
NDP, NDN	Desired number of positive and negative roots (Default = 3 NEP) (Integer > 0)
E	Convergence criteria (optional) (Real $\geq$ 0.0)
NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT"
	MAX - Normalize to unit value of the largest component in the analysis set
	PØINT - Normalize to unit value of the component defined in fields 3 and 4 defaults to "MAX" if defined component is zero.
G	Grid or scalar point identification number (Integer > 0) (Required if and only if NØRM = "PØINT")
C	Component number (One of the integers 1-6) (Required if and only if NØRM = "PØINT" and G is a geometric grid point)

Remarks:

1. Buckling analysis root extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

2. The quantities L1 and L2 are dimensionless and specify a range in which the eigenvalues are to be found. An eigenvalue is a factor by which the prebuckling state of stress (first subcase) is multiplied to produce buckling.

3. The continuation card is required.

4. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.

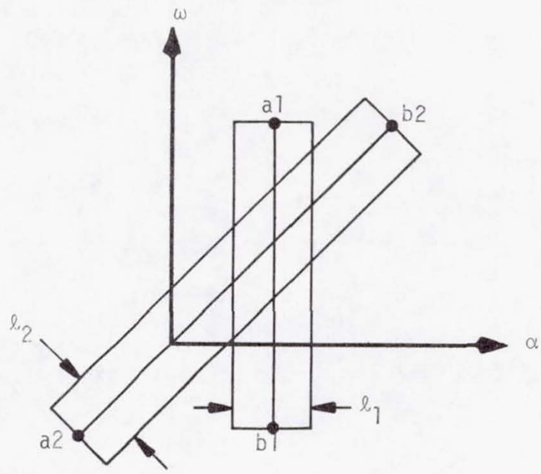
5. If METHØD = DET, L1 must be greater than or equal to 0.0.

6. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.

7. If NØRM = PØINT, the selected component must be in the analysis set.

Input Data Card EIGC Complex Eigenvalue Extraction Data

Description: Defines data needed to perform complex eigenvalue analysis.



Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGC	SID	METHØD	NØRM	G	C	E			+abc
EIGC	14	DET	PØINT	27		1.-8			ABC
+abc	α_{a1}	ω_{a1}	α_{b1}	ω_{b1}	ℓ_1	N_{e1}	N_{d1}		+def
+BC	2.0	5.6	2.0	-3.4	2.0	4	4		DEF
+def	α_{a2}	ω_{a2}	α_{b2}	ω_{b2}	ℓ_2	N_{e2}	N_{d2}		
+EF	-5.5	-5.5	5.6	5.6	1.5	6	3		

(etc.)

Field	Contents
SID	Set identification number (Unique integer > 0)
METHØD	Method of complex eigenvalue extraction, one of the BCD values "INV" or "DET" INV - Inverse power method DET - Determinant method
NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT" MAX - Normalize to a unit value for the real part and a zero value for the imaginary part, the component having the largest magnitude PØINT - Normalize to a unit value for the real part and a zero value for the imaginary part the component defined in fields 5 and 6 - defaults to "MAX" if the magnitude of the defined component is zero.

G	Grid or scalar point identification number (Required if and only if NØRM=PØINT) (Integer > 0)
C	Component number (Required if and only if NØRM="PØINT" and G is a geometric grid point) ($0 \leq$ integer ≥ 6)
E	Convergence criterion (optional) (Real ≥ 0.0)
$(\alpha_{aj}, \omega_{aj})$ $(\alpha_{bj}, \omega_{bj})$	Two complex points defining a line in the complex plane (Real)
ℓ_j	Width of region in complex plane (Real > 0.0)
N_{ej}	Estimated number of roots in each region (Integer > 0)
N_{dj}	Desired number of roots in each region (Default is $3N_{ej}$) (Integer > 0)

Remarks:

1. Each continuation card defines a rectangular search region. Any number of regions may be used and they may overlap. Roots in overlapping regions will not be extracted more than once.

2. Complex eigenvalue extraction data sets must be selected in the Case Control Deck (CMETHØD=SID) to be used by NASTRAN.

3. The units of α, ω are radians per unit time.

4. At least one continuation card is required.

5. For the determinant method with no damping matrix, complex conjugates of the roots found are not printed.

6. See Section 10.4.4.5 of the Theoretical Manual for a discussion of convergence criteria.

Input Data Card EIGP Poles in Complex Plane

Description: Defines poles that are used in complex eigenvalue extraction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGP	SID	α	ω	M	α	ω	M		
EIGP	15	-5.2	0.0	2	6.3	5.5	3		

Field	Contents
SID	Set identification number (Integer > 0)
(α,ω)	Coordinates of point in complex plane (Real)
M	Multiplicity of complex root at pole defined by (α,ω) (Integer > 0)

Remarks:
1. Defines poles in complex plane that are used with associated EIGC card having same set number.
2. The units of α,ω are radians per unit time.
3. Poles are used only in the Determinent Method.
4. One or two poles may be defined on a single card.

Input Data Card EIGR   Real Eigenvalue Extraction Data

Description: Defines data needed to perform real eigenvalue analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGR	SID	METHØD	F1	F2	NE	ND	NZ	E	+abc
EIGR	13	DET	1.9	15.6	10	12	0	1.-3	ABC
+abc	NØRM	G	C						
+BC	PØINT	32	4						

Field

SID — Set identification number (Unique integer > 0)

METHØD — Method of eigenvalue extraction, one of the BCD values "INV", "DET", "GIV", "UINV", or "UDET".

- INV - Inverse power method, symmetric matrix operations.
- DET - Determinant method, symmetric matrix operations.
- GIV - Givens method of tridiagonalization.
- UINV - Inverse power method, unsymmetric matrix operations.
- UDET - Determinant method, unsymmetric matrix operations.

F1,F2 — Frequency range of interest (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Real $\geq$ 0.0; F1 < F2). Frequency range over which eigenvectors are desired for METHØD = "GIV". The frequency range is ignored if ND > 0, in which case the eigenvectors for the first ND positive roots are found. (Real, F1 $\geq$ 0.0, F2 > 0.0)

NE — Estimate of number of roots in range (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Integer > 0)

ND — Desired number of roots for METHØD = "DET", "INV", "UDET", or "UINV" (Default is 3 NE) (Integer > 0). Desired number of eigenvectors for METHØD = "GIV" (Default is zero) (Integer $\geq$ 0)

NZ — Number of free body modes (Optional - used only if METHØD = "DET" or "UDET") (Integer $\geq$ 0)

E — Mass orthogonality test parameter (Default is 0.0 which means no test will be made) (Real $\geq$ 0.0)

NØRM — Method for normalizing eigenvectors, one of the BCD values "MASS", "MAX" or "PØINT"

- MASS - Normalize to unit value of the generalized mass
- MAX - Normalize to unit value of the largest component in the analysis set
- PØINT - Normalize to unit value of the component defined in fields 3 and 4 - defaults to "MAX" if defined component is zero

G	Grid or scalar point identification number (Required if and only if NØRM="PØINT") (Integer $\geq$ 0)
C	Component number (One of the integers 1-6) (Required if and only if NØRM="PØINT" and G is a geometric grid point)

Remarks:

1. Real eigenvalue extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

2. The units of F1 and F2 are cycles per unit time.

3. The continuation card is required.

4. If METHØD = "GIV", all eigenvalues are found.

5. If METHØD = "GIV", the mass matrix for the analysis set must be positive definite. This means that all degrees of freedom, including rotations, must have mass properties. ØMIT cards may be used to remove massless degrees of freedom.

6. A nonzero value of E in field 9 also modifies the convergence criteria. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.

7. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.

8. If NØRM = PØINT, the selected component must be in the analysis set.

Input Data Card EPØINT Extra Point

Description: Defines extra points of the structural model for use in dynamics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
EPØINT	3	18	1	4	16	2			

Alternate Form

EPØINT	ID1	"THRU"	ID2						
EPØINT	17	THRU	43						

Field	Contents
ID,ID1,ID2	Extra point identification number (Integer > 0; ID1 < ID2)

Remarks:
1. All extra point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
2. This card is used to define coordinates used in transfer function definitions (see TF card).
3. If the alternate form is used, extra points ID1 thru ID2 are defined.

NASTRAN DATA DECK

Input Data Card FLSYM Axisymmetric Symmetry Control

Description: Defines the relationship between the axisymmetric fluid and a structural boundary having symmetric constraints. The purpose is to allow fluid boundary matrices to conform to structural symmetry definitions.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLSYM	M	S1	S2						
FLSYM	12	S	A						

Field	Contents
M	Number of symmetric sections of structural boundary around circumference of fluid being modeled by the set of structural elements (Integer ≥ 2, even)
S1, S2	Description of boundary constraints used on structure at first and second planes of symmetry. (BCD: "S" $\Rightarrow$ symmetric, "A" $\Rightarrow$ antisymmetric)

Remarks:
1. This card is allowed only if an AXIF card is also present.
2. Only one (1) FLSYM card is allowed.
3. The card is not required if no planes of symmetry are involved.
4. First plane of symmetry is assumed to be at $\phi = 0$. Second plane of symmetry is assumed to be at $\phi = 360°/M$.
5. Symmetric and antisymmetric constraints for the structure must, in addition, be provided by the user.
6. The solution is performed for those harmonic indices listed on the AXIF card that are compatible with the symmetry conditions.

Example: If a quarter section of structure is used to model the boundary, M = 4. If the boundary constraints are S-S, the compatible cosine harmonics are: 0, 2, 4, etc. If S-A is used the compatible cosine harmonics are 1, 3, 5, ..., etc.

Input Data Card FØRCE Static Load

Description: Defines a static load at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE	SID	G	CID	F	N1	N2	N3		
FØRCE	2	5	6	2.9	0.0	1.0	0.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
F	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The static load applied to grid point G is given by

$$\vec{f} = F \vec{N}$$

where $\vec{N}$ is the vector defined in fields 6, 7 and 8.

2. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.

3. A CID of zero references the basic coordinate system.

Input Data Card FØRCE1 Static Load

Description: Used to define a static load by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE1	SID	G	F	G1	G2				
FØRCE1	6	13	-2.93	16	13				

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
F	Value of load (Real)
G1, G2	Grid point identification numbers (Integer > 0; G1 ≠ G2)

Remarks: 1. The direction of the force is determined by the vector from G1 to G2.

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card FØRCE2 Static Load

Description: Used to define a static load by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE2	SID	G	F	G1	G2	G3	G4		
FØRCE2	6	13	-2.93	16	13	17	13		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
F	Value of load (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G1 ≠ G2; G3 ≠ G4)

Remarks: 1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card FØRCEAX   Conical Shell Static Load

Description: Defines a static loading of a conical shell coordinate.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCEAX	SID	RID	HID	S	FR	FP	FZ		
FØRCEAX	1	2	3	2.0	0.1	0.2	0.3		

Field	Contents
SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer > 0)
HID	Harmonic identification number (Integer $\geq$ 0 or a sequence of harmonics, see note 5)
S	Scale factor for load (Real)
FR, FP, FZ	Load components in r, ϕ, z directions (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.

2. Axisymmetric shell loads must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

3. A separate card is needed for the definition of the force associated with each harmonic.

4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

5. If a sequence of harmonics is to be placed in HID the form is as follows: "Sn1Tn2" where n1 is the start of the sequence and n2 is the end of the sequence. i.e., for harmonics 0 through 10, the field would contain "S0T10".

Input Data Card FREEPT Fluid Free Surface Point

Description: Defines the location of points on the surface of a fluid for recovery of surface displacements in a gravity field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREEPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
FREEPT	3		301	22.5	302	90.0	303	370.0	

Field	Contents
IDF	Fluid point (RINGFL) identification number (Integer > 0)
IDP	Free surface point identification number (Integer > 0)
ϕ	Azimuthal position of FREEPT on fluid point (RINGFL), in Fluid Coordinate System (Real)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. All free surface point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. The free surface points are used for the identification of output data only.
4. Three points may be defined on a single card.
5. The referenced fluid point (IDF) must be included in a free surface list (FSLIST).
6. Output requests for velocity and acceleration can be made at these points.

Input Data Card FREQ Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ	SID	F	F	F	F	F	F	F	abc
FREQ	3	2.98	3.05	17.9	21.3	25.6	28.8	31.2	ABC

+bc	F	F	F	F	F	F	F	F	
+BC	29.2	22.4	19.3						

-etc.-

Field	Contents
SID	Frequency set identification number (Integer > 0)
F	Frequency value (Real > 0.0)

Remarks:
1. The units for the frequencies are cycles per unit time.
2. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
3. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

Input Data Card FREQ1 Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, frequency increment, and number of increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ1	SID	F1	DF	NDF					
FREQ1	6	2.9	0.5	13					

Field	Contents
SID	Frequency set identification number (Integer > 0)
F1	First frequency in set (Real $\geq$ 0.0)
DF	Frequency increment (Real > 0.0)
NDF	Number of frequency increments (Integer > 0)

Remarks:

1. The units for the frequency F1 and the frequency increment DF are cycles per unit time.

2. The frequencies defined by this card are given by

$$f_i = F1 + (i - 1) DF, \quad i = 1, NDF + 1$$

3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.

4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

Input Data Card FREQ2 Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, final frequency, and number of logarithmic increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ2	SID	F1	F2	NF					
FREQ2	6	1.0	1.E5	5					

Field	Contents
SID	Frequency set identification number (Integer > 0)
F1	First frequency (Real > 0.0)
F2	Last frequency (Real > 0.0; F2 > F1)
NF	Number of logarithmic intervals (Integer > 0)

Remarks:

1. The units for the frequencies F1 and F2 are cycles per unit time.
2. The frequencies defined by this card are given by

$$f_i = F1 \cdot e^{(i-1)d}, \qquad i = 1,2,\ldots,NF + 1$$

where

$$d = \frac{1}{NF} \log_e \frac{F2}{F1}$$

For the example shown, the list of frequencies will be 1.0, 10.0, 100.0, 1000.0, 10000.0, and 100000.0 cycles per unit time.

3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

NASTRAN DATA DECK

Input Data Card FSLIST   Free Surface List

Description: Declares the fluid points (RINGFL) which lie on a free surface boundary.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FSLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
FSLIST	1.0-4	1	3	5	4	2	7	6	+12FS

+bc	IDF8	IDF9	-etc.-						def
+12FS	8	9	10	11	AXIS				

-etc.-

Field	Contents
RHØ	Mass density at the surface (Real > 0.0 or blank; if blank the AXIF default value must not be blank)
IDFi	Identification number of RINGFL point (Integer > 0 or BCD, "AXIS." The first and/or last entry may be AXIS)

Remarks:

1. This card is allowed only if an AXIF card is also present.

2. Each logical card defines a surface. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.

3. The BCD word, AXIS, defines an intersection with the polar axis of the Fluid Coordinate System.

4. There may be as many FSLIST cards as the user requires. If the fluid density varies along the boundary there must be one FSLIST card for each interval between fluid points.

Input Data Card GENEL General Element

Description: Defines a general element using either:

1. The stiffness approach:

$$\begin{Bmatrix} f_i \\ --- \\ f_d \end{Bmatrix} = \left[\begin{array}{c|c} K & -KS \\ \hline -S^T K & S^T KS \end{array}\right] \begin{Bmatrix} u_i \\ --- \\ u_d \end{Bmatrix} \quad \text{, or}$$

2. The flexibility approach:

$$\begin{Bmatrix} u_i \\ --- \\ f_d \end{Bmatrix} = \left[\begin{array}{c|c} Z & S \\ \hline -S^T & 0 \end{array}\right] \begin{Bmatrix} f_i \\ --- \\ u_d \end{Bmatrix} \quad \text{, where}$$

$$\{u_i\} = [u_{i1}, u_{i2}, \ldots, u_{im}]^T ,$$

$$\{u_d\} = [u_{d1}, u_{d2}, \ldots, u_{dn}]^T ,$$

$$[KZ] = [K] \text{ or } [Z] = \begin{bmatrix} KZ_{11} & KZ_{12} & \cdots & KZ_{1m} \\ \cdot & KZ_{22} & \cdots & \cdot \\ \vdots & \vdots & & \vdots \\ KZ_{m1} & \cdots & \cdots & KZ_{mm} \end{bmatrix} \text{ and } [KZ]^T = [KZ] ,$$

$$[S] = \begin{bmatrix} S_{11} & \cdots & S_{1n} \\ \vdots & & \vdots \\ S_{m1} & \cdots & S_{mn} \end{bmatrix}$$

The required input is the $\{u_i\}$ list and the lower triangular portion of [K] or [Z]. Additional input may include the $\{u_d\}$ list and [S]. If [S] is input, $\{u_d\}$ must also be input. If $\{u_d\}$ is input but [S] is omitted, [S] is internally calculated. In this case, $\{u_d\}$ must have six and only six degrees of freedom. If [S] is not required, both $\{u_d\}$ and [S] are omitted.

Format: (An example is given on the following page.)

1	2	3	4	5	6	7	8	9	10
GENEL	EID		UI1	CI1	UI2	CI2	UI3	CI3	X1
+1	UI4	CI4	UI5	CI5	UI6	CI6	UI7	CI7	X2
+2				Etc.					X3
+3	UI_m	- The last item in the UI-list will appear in one of fields 2, 4, 6, or 8.							X4
+4	"UD"		UD1	CD1	UD2	CD2	UD3	CD3	X5
+5				Etc.					X6
+6	UD_n	- The last item in the UD list will appear in one of fields 2, 4, 6, or 8.							X7
+7	"K" or "Z"	KZ11	KZ21	KZ31	Etc.		KZ22	KZ32	X8
+8	Etc.		KZ33	KZ43	Etc.				X9
+9				Etc.					X10
+10	KZ_{mm}	- The last item in the K or Z matrix, will appear in one of fields 2 through 9.							X11
+11	"S"	S11	S12	Etc.		S21	Etc.		X12
+12	S_{mn}	- The last item in the S matrix will appear in one of fields 2 through 9.							

Field	Contents
EID	Unique element identification number, a positive integer.
UI1, CI1 Etc. UD1, ED1 Etc.	Identification numbers of coordinates in the UI or UD list, in sequence corresponding to the [K], [Z], and [S] matrices. U_i and UD_i are grid point numbers, and CI_i and CD_i are the component numbers. If a scalar point is given, the component number is zero.
KZ_{ij}	Values of the [K] or [Z] matrix ordered by columns from the diagonal, according to the UI list.
S_{ij}	Values of the [S] matrix ordered by rows, according to the UD list.
"UD", "K", "Z", and "S"	BCD data words which indicate the start of data belonging to UD, [K], [Z], or [S].

Remarks:

1. When the stiffness matrix, K, is input, the number of significant digits should be the same for all terms.

2. Double-field format may be used for input of K or Z.

Example: Let element 629 be defined by

$$\{u_i\} = [1\text{-}1, 13\text{-}4, 42, 24\text{-}2]^T ,$$

$$\{u_d\} = [6\text{-}2, 33]^T ,$$

where i-j means the j^{th} component of grid point i. Points 42 and 33 are scalar points.

$$[K] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 2.0 & 5.0 & 6.0 & 7.0 \\ 3.0 & 6.0 & 8.0 & 9.0 \\ 4.0 & 7.0 & 9.0 & 0.0 \end{bmatrix} , \qquad [S] = \begin{bmatrix} 1.5 & 2.5 \\ 3.5 & 4.5 \\ 5.5 & 6.5 \\ 7.5 & 8.5 \end{bmatrix}$$

The data cards necessary to input this general element are shown below:

1	2	3	4	5	6	7	8	9	10
GENEL	629		1	1	13	4	42	0	X1
+1	24	2							X2
+2	UD		6	2	33	0			X3
+3	Z	1.0	2.0	3.0	4.0	5.0	6.0	7.0	X4
+4	8.0	9.0	0.0						X5
+5	S	1.5	2.5	3.5	4.5	5.5	6.5	7.5	X6
+6	8.5								

Input Data Card GRAV Gravity Vector

Description: Used to define gravity vectors for use in determining gravity loading for the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRAV	SID	CID	G	N1	N2	N3			
GRAV	1	3	32.2	0.0	0.0	-1.0			

Field	Contents
SID	Set identification number (Integer > 0)
CID	Coordinate system identification number (Integer $\geq$ 0)
G	Gravity vector scale factor (Real)
N1, N2, N3	Gravity vector components (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The gravity vector is defined by

$$\vec{g} = G \cdot (N1, N2, N3).$$

2. A CID of zero references the basic coordinate system.

3. Gravity loads may be combined with "simple loads" (e.g., FØRCE, MØMENT) only by specification on a LØAD card. That is, the SID on a GRAV card may not be the same as that on a simple load card.

4. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card GRDSET Grid Point Default

Description: Defines default options for fields 3, 7 and 8 of all GRID cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRDSET		CP				CD	PS		
GRDSET		16				32	3456		

Field	Contents
CP	Identification number of coordinate system in which the location of the grid point is defined (Integer ≥ 0)
CD	Identification number of coordinate system in which displacements are measured at grid point (Integer ≥ 0)
PS	Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer ≥ 0)

Remarks:

1. The contents of fields 3, 7 or 8 of this card are assumed for the corresponding fields of any GRID card whose field 3, 7 and 8 are blank. If any of these fields on the GRID card are blank, the default option defined by this card occurs for that field. If no permanent single-point constraints are desired or one of the coordinate systems is basic, the default may be overridden on the GRID card by making one of fields 3, 7 or 8 zero (rather than blank). Only one GRDSET card may appear in the user's Bulk Data Deck.
2. The primary purpose of this card is to minimize the burden of preparing data for problems with a large amount of repetition (e.g., two-dimensional pinned-joint problems).
3. At least one of the entries CP, CD, or PS must be nonzero.

Input Data Card GRID   Grid Point

Description: Defines the location of a geometric grid point of the structural model, the directions of its displacement, and its permanent single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRID	ID	CP	X1	X2	X3	CD	PS		
GRID	2	3	1.0	2.0	3.0		316		

Field	Contents
ID	Grid point identification number (Integer > 0)
CP	Identification number of coordinate system in which the location of the grid point is defined (Integer $\geq$ 0 or blank*).
X1,X2,X3	Location of the grid point in coordinate system CP (Real)
CD	Identification number of coordinate system in which displacements, degrees of freedom, constraints, and solution vectors are defined at the grid point (Integer $\geq$ 0 or blank*)
PS	Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer $\geq$ 0 or blank*)

Remarks:

1. All grid point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
2. The meaning of X1, X2 and X3 depend on the type of coordinate system, CP, as follows: (see CØRD__ card descriptions)

Type	X1	X2	X3
Rectangular	X	Y	Z
Cylindrical	R	Θ(degrees)	Z
Spherical	R	Θ(degrees)	Φ(degrees)

3. The collection of all CD coordinate systems defined on all GRID cards is called the Global Coordinate System. All degrees-of-freedom, constraints, and solution vectors are expressed in the Global Coordinate System.

* See the GRDSET card for default options for fields 3, 7 and 8.

Input Data Card GRIDB Axisymmetric Problem Grid Point

Description: Defines the location of a geometric grid point on a RINGFL for an axisymmetric fluid model and/or axisymmetric structure. Used to define the boundary of the fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDB	ID			ϕ		CD	PS	IDF	
GRIDB	30			30.0		3	345	20	

Field	Contents
ID	Grid point identification number (Integer > 0)
ϕ	Azimuthal position in the fluid in degrees (Real)
CD	Identification number of the coordinate system in which displacements are defined at the grid point (Integer $\geq$ 0)
PS	Permanent single-point constraints associated with the grid point (any combination of the digits 1-6 with no embedded blanks) (Integer $\geq$ 0)
IDF	Identification number of a RINGFL (Integer > 0)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. All GRIDB identification numbers must be unique with respect to other scalar, structural and fluid points.
3. An AXIF card must define a Fluid Coordinate System.
4. The RINGFL referenced must be present.
5. If no harmonic numbers on the AXIF card are specified, no fluid elements are necessary.
6. The collection of all CD coordinate systems defined on all GRID and GRIDB cards is called the Global Coordinate System.
7. Fields 3, 4, and 6 are ignored. This will facilitate the user's conversion of GRID cards to GRIDB cards. Note that the fields are the same except for fields 1 and 9 if a cylindrical coordinate system is used.
8. The referenced RINGFL point must be included in a boundary list (BDYLIST data card).

Input Data Card GRIDF   Fluid Point

Description: Defines a scalar degree of freedom for harmonic analysis of a fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDF	ID	R	Z						
GRIDF	23	2.5	-7.3						

Field	Contents
ID	Identification number of axisymmetric fluid point (Integer > 0)
R	Radial location of point in basic coordinate system (Real > 0.0)
Z	Axial location of point in basic coordinate system (Real)

Remarks:
1. This card is allowed only if an AXSLØT card is also present.
2. The identification number (ID) must be unique with respect to all other scalar, structural and fluid points.
3. Grid points on slot boundaries are defined on GRIDS cards. Do not also define them on GRIDF cards.
4. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. Pressures will be plotted as displacement in the basic Z direction.
5. Load and constraint conditions are applied as if the GRIDF is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

Input Data Card GRIDS Slot Surface Point

Description: Defines a scalar degree of freedom with a two dimensional location. Used in defining pressure in slotted acoustic cavities.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDS	ID	R	Z	W	IDF				
GRIDS	25	2.5	-7.3	0.5					

Field	Contents
ID	Identification number of slot point (Integer > 0)
R	Radial location of point in basic coordinate system (Real $\neq$ 0.0)
Z	Axial location of point in basic coordinate system (Real)
W	Slot width or thickness at the GRIDS point (Real $\geq$ 0.0, or "blank")
IDF	Identification number to define a GRIDF point (Integer > 0, or "blank")

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. The identification numbers (ID and IDF if present) must be unique with respect to all other scalar, structural and fluid points.
3. If W is "blank", the default value on the AXSLØT card will be used.
4. The IDF number is referenced on the CAXIFi card for central cavity fluid elements next to the interface. The IDF number is entered only if the grid point is on an interface. In this case it should not also be defined on a GRIDF card.
5. If IDF is nonzero then R must be greater than zero.
6. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. The slot width, W, corresponds to the basic Z coordinate. The pressure will be plotted in the basic Z direction.
7. Load and constraint conditions are applied as if the GRIDS is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

Input Data Card LØAD Static Load Combination (Superposition)

Description: Defines a static load as a linear combination of load sets defined via FØRCE, MØMENT, FØRCE1, MØMENT1, FØRCE2, MØMENT2, PLØAD, PLØAD2, SLØAD, RFØRCE and GRAV cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØAD	SID	S	S1	L1	S2	L2	S3	L3	abc
LØAD	101	-0.5	1.0	3	6.2	4			

+bc	S4	L4		-etc.-					

(etc.)

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale factor (Real)
Si	Scale factors (Real)
Li	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks:

1. The load vector defined is given by

$$\{P\} = S \sum_i S_i \{P_{Li}\}$$

2. The Li must be unique. The remainder of the physical card containing the last entry must be blank.
3. This card must be used if gravity loads (GRAV) are to be used with any of the other types.
4. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
5. A LØAD card may not reference a set identification number defined by another LØAD card.

Input Data Card MAT1 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHØ	A	TREF	GE	+abc
MAT1	17	3.+7	1.9+7		4.28	0.19	5.37+2	0.23	ABC
+abc	ST	SC	SS						
+BC	20.+4	15.+4	12.+4						

Field	Contents
MID	Material identification number (Integer > 0)
E	Young's modulus (Real ≥ 0.0 or blank)
G	Shear modulus (Real ≥ 0.0 or blank)
NU	Poisson's ratio (-1.0 < Real ≤ 0.5 or blank)
RHØ	Mass density (Real)
A	Thermal expansion coefficient (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Used only to compute margins of safety in certain elements; they have no effect on the computational procedures)

Remarks:

1. One of E or G must be positive (i.e., either E > 0.0 or G > 0.0 or both E and G may be > 0.0).
2. If any one of E, G or NU is blank, it will be computed to satisfy the identity E = 2(1+NU)G; otherwise, values supplied by the user will be used.
3. The material identification number must be unique for all MAT1, MAT2 and MAT3 cards.
4. MAT1 materials may be made temperature dependent by use of the MATT1 card.
5. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
6. If E and NU or G and NU are both blank they will be both given the value 0.0.
7. Weight density may be used in field 6 if the value $\frac{1}{g}$ is entered on the PARAM card WTMASS, where g is the acceleration of gravity (see Section 3.1.5).

Input Data Card MAT2 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT2	MID	G11	G12	G13	G22	G23	G33	RHØ	+abc
MAT2	13	6.2+3			6.2+3		5.1+3	0.056	ABC
+abc	A1	A2	A12	T0	GE	ST	SC	SS	
+BC	0.15			-500.0	0.002	20.+5			

Field	Contents
MID	Material identification number (Integer > 0)
Gij	The material property matrix (Real)
RHØ	Mass density (Real)
Ai	Thermal expansion coefficient vector (Real)
T0	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Used only to compute margins of safety in certain elements; they have no effect on the computational procedures)

Remarks:

1. The material identification numbers must be unique for all MAT1, MAT2 and MAT3 cards.
2. MAT2 materials may be made temperature dependent by use of the MATT2 card.
3. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
4. The convention for the G_{ij} in fields 3 through 8 are represented by the matrix relationship

$$\begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{Bmatrix} = \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{12} & G_{22} & G_{23} \\ G_{13} & G_{23} & G_{33} \end{bmatrix} \begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12} \end{Bmatrix}$$

Input Data Card MAT3 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, orthotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT3	MID	EX	EY	EZ	NUXY	NUYZ	NUZX	RHØ	+abc
MAT3	23	1.0+7	1.1+7	1.2+7	.3	.25	.27	1.0-5	ABC
+abc	GXY	GYZ	GZX	AX	AY	AZ	TREF	GE	
+BC	2.5+6	3.0+6	2.5+6	1.0-4	1.0-4	1.1-4	68.5	.23	

Field	Contents
MID	Material identification number (Integer > 0)
EX, EY, EZ	Young's moduli in the x, y and z directions respectively (Real $\geq$ 0.0)
NUXY,NUYZ,NUZX	Poisson's Ratios (Coupled strain ratios in the xy, zy and zx directions respectively) (Real)
RHØ	Mass density (Real)
GXY, GYZ, GZX	Shear moduli for xy, yz and zx (Real $\geq$ 0.0)
AX, AY, AZ	Thermal expansion coefficients (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)

Remarks:

1. The material identification number must be unique with respect to the collection of all MAT1, MAT2 and MAT3 cards.
2. MAT3 materials may be made temperature-dependent by use of the MATT3 card.
3. All nine of the numbers EX, EY, EZ, NUXY, NUYZ, NUZX, GXY, GYZ and GZX must be present.
4. A nonfatal warning diagnostic will occur if any of NUXY or NUYZ has an absolute value greater than 1.0.
5. MAT3 materials may only be referenced by CTRIARG, CTRAPRG and PTØRDRG cards.
6. The mass density, RHØ, will be used to automatically compute mass for the TRIARG, TRAPRG and TØRDRG elements.

Input Data Card MAT4 Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT4	MID	K	CP						
MAT4	103	.6	.2						

Field	Contents
MID	Material identification number (Integer > 0)
K	Thermal conductivity (Real > 0.0), or convective film coefficient
CP	Thermal capacity per unit volume (Real > 0.0 or blank), or film capacity per unit area

Remarks:

1. The material identification number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to other MAT4 or MAT5 cards.
2. If a HBDY element references this card, K is the convective film coefficient and CP is the thermal capacity per unit area.
3. MAT4 materials may be made temperature dependent by use of the MATT4 card.

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Input Data Card MAT5 Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT5	MID	KXX	KXY	KXZ	KYY	KYZ	KZZ	CP	
MAT5	24	.092			.083		.020	0.2	

Field	Contents
MID	Material identification number (Integer > 0)
KXX,KXY,KXZ, KYY,KYZ,KZZ	Thermal conductivity (Real)
CP	Thermal capacity per unit volume (Real $\geq$ 0.0 or blank)

Remarks:

1. The thermal conductivity matrix has the form:

$$K = \begin{bmatrix} KXX & KXY & KXZ \\ KXY & KYY & KYZ \\ KXZ & KYZ & KZZ \end{bmatrix}$$

2. The material number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to the MAT4 or MAT5 cards.

3. MAT5 materials may be made temperature dependent by use of the MATT5 card.

Input Data Card MATS1 Material Stress Dependence

Description: Specifies table references for material properties which are stress-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATS1	MID	R1							+abc
MATS1	17	28							ABC

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
R1	Reference to table identification number (Integer ≥ 0)

Remarks:
1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.
2. TABLES1 type tables must be used.

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Input Data Card MATT1 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT1	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT1	17	32				15			ABC
+abc	R8	R9	R10						
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks:

1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.

2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT2 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT2	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT2	17	32				15			ABC

+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT2 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks: 1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT2 card.

2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT3 Material Temperature Dependence

Description: Specifies table references for orthotropic, "MAT3", material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT3	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT3	23	48			54				ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	74								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT3 card (Integer > 0)
Ri	References to table identification numbers (Integer $\geq$ 0)

Remarks:
1. Blank or zero entries imply no table dependence of the referenced quantity on the basic MAT3 card.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

Input Data Card MATT4 Thermal Material Temperature Dependence

Description: Specifies table reference for temperature dependent thermal conductivity or convective film coefficient.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT4	MID	T(K)							
MATT4	103	73							

Field	Contents
MID	ID of a MAT4 which is to be temperature dependent (Integer > 0)
T(K)	Identification number of a TABLEMi card which gives temperature dependence of the thermal conductivity or convective film coefficient (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent; field 4 must be blank.
2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT4 card is always multiplied by the tabular function. Note that this is different from structural applications.
3. Blank or zero entries means no table dependence of the referenced quantity on the basic MAT4 card.

Input Data Card MATT5 Thermal Material Temperature Dependence

Description: Specifies table references for temperature dependent conductivity matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT5	MID	T(KXX)	T(KXY)	T(KXZ)	T(KYY)	T(KYZ)	T(KZZ)		
MATT5	24	73							

Field	Contents
MID	Identification number of a MAT5, which is to be temperature dependent (Integer > 0)
T(K--)	Identification number of a TABLEMi card which gives temperature dependence of the matrix term (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent. Field 9 must be blank.

2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT5 card are always multiplied by the tabular function. Note that this is different from the structural applications.

3. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT5 card.

Input Data Card MØMAX Conical Shell Static Moment

Description: Defines a static moment loading of a conical shell coordinate.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMAX	SID	RID	HID	S	MR	MP	MZ		
MØMAX	1	2	3	1.0	0.1	0.2	0.3		

Field	Contents
SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
HID	Harmonic identification number (Integer $\geq$ 0 or a sequence of harmonics,see note 5)
S	Scale factor (Real)
MR, MP, MZ	Moment components in the r, ϕ, z directions (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. A separate card is needed for the definition of the moment associated with each harmonic.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. If a sequence of harmonics is to be placed in HID the form is as follows: "Sn1Tn2" where n1 is the start of the sequence and n2 is the end of the sequence i.e., for harmonics 0 through 10, the field would contain "S0T10".

Input Data Card MØMENT Static Moment

Description: Defines a static moment at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT	SID	G	CID	M	N1	N2	N3		
MØMENT	2	5	6	2.9	0.0	1.0	0.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer $\geq$ 0)
M	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks:

1. The static moment applied to grid point G is given by

$$\vec{m} = M \cdot (N1, N2, N3)$$

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

3. A CID of zero references the basic coordinate system.

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Input Data Card MØMENT1 Static Moment

Description: Used to define a static moment by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT1	SID	G	M	G1	G2				
MØMENT1	6	13	-2.93	16	13				

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
M	Value of moment (Real)
G1, G2	Grid point identification numbers (Integer > 0; G1 $\neq$ G2)

Remarks: 1. The direction of the moment is determined by the vector from G1 to G2.

2. Load sets must be selected in the Case Control Deck (LØAD-SID) to be used by NASTRAN.

Input Data Card MØMENT2 Static Moment

Description: Used to define a static moment by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT2	SID	G	M	G1	G2	G3	G4		
MØMENT2	6	13	-2.93	16	13	17	13		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
M	Value of moment (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G1 $\neq$ G2; G3 $\neq$ G4)

Remarks:
1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card MPC Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPC	SID	G	C	A	G	C	A		abc
MPC	3	28	3	6.2	2		4.29		+B

+bc		G	C	A	-etc.-				
+B		1	4	-2.91					

Field	Contents
SID	Set identification number (Integer > 0)
G	Identification number of grid or scalar point (Integer > 0)
C	Component number - any one of the digits 1-6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer)
A	Coefficient (Real; the first A must be nonzero)

Remarks:

1. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
2. Forces of multipoint constraint are not recovered.
3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
4. Dependent coordinates on MPC cards may not appear on ØMIT, ØMIT1, SUPØRT, SPC or SPC1 cards.

Input Data Card MPCADD Multipoint Constraint Set Definition

Description: Defines a multipoint constraint set as a union of multipoint constraint sets defined via MPC cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
MPCADD	101	2	3	1	6	4			

+bc	S8	S9	-etc.-						

Field	Contents
SID	Set identification number (Integer > 0)
Sj	Set identification numbers of multipoint constraint sets defined via MPC cards (Integer > 0)

Remarks:

1. The Sj must be unique.
2. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
3. Sj may not be the identification number of a multipoint constraint set defined by another MPCADD card.

Input Data Card MPCAX   Conical Shell Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

for conical shell coordinates.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCAX	SID				RID	HID	C	A	+abc
MPCAX	32				17	6	1	1.0	+1
+abc	RID	HID	C	A	RID	HID	C	A	+def
+1	23	4	2	-6.8					

-etc.-

Field	Contents
SID	Set identification number (Integer > 0)
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer > 0)
C	Component number ($1 \leq$ Integer ≤ 6)
A	Coefficient (Real; the first A must be nonzero)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
4. Dependent coordinates appearing on MPCAX cards may not appear on ØMITAX, SPCAX, or SUPAX cards.
5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card NØLIN1 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\ T(u_j(t))$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN1	SID	GI	CI	S	GJ	CJ	T		
NØLIN1	21	3	4	2.1	3	1	6		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
T	Identification number of a TABLEDi card (Integer > 0)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN1 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card NØLIN2 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\ u_j(t)u_k(t)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN2	SID	GI	CI	S	GJ	CJ	GK	CK	
NØLIN2	14	2	1	2.9	2	1	2	1	

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
GK	Grid or scalar or extra point identification number (Integer > 0)
CK	Component number of GK a grid point (0 < Integer ≤ 6); blank or zero if GK is a scalar or extra point

Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN2 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

Input Data Card NØLIN3 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} S\left(u_j(t)\right)^A, & u_j(t) > 0 \\ 0, & u_j(t) \le 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN3	SID	GI	CI	S	GJ	CJ	A		
NØLIN3	4	102		-6.1	2	5	-3.5		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point ($0 < \text{Integer} \le 6$); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point ($0 < \text{Integer} \le 6$); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN3 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

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Input Data Card NØLIN4 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} -S\left(-u_j(t)\right)^A & , \quad u_j(t) < 0 \\ 0 & , \quad u_j(t) \geq 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN4	SID	GI	CI	S	GJ	CJ	A		
NØLIN4	2	4	6	2.0	101		16.3		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN4 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

NASTRAN DATA DECK

Input Data Card ØMIT   Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT	ID	C	ID	C	ID	C	ID	C	
ØMIT	16	2	23	3516			1	4	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks: 1. Coordinates specified on ØMIT cards may not be specified on ØMIT1, ASET, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multi-point constraint relations (MPC) or as permanent single-point constraints on GRID card.

2. As many as 24 coordinates may be omitted by a single card.

Input Data Card ØMIT1 Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT1	C	G	G	G	G	G	G	G	abc
ØMIT1	3	2	1	3	10	9	6	5	ABC

+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ØMIT1	C	ID1	"THRU"	ID2					
ØMIT1	0	17	THRU	109					

Field Contents

C Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points)

G,ID1,ID2 Grid or scalar point identification number (Integer > 0; ID1 < ID2)

Remarks: 1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC, SPC1, ØMIT, ASET, ASET1, or SUPØRT card or on a GRID card as permanent single-point constraints.

2. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

Input Data Card ØMITAX   Omitted Conical Shell Coordinate

Description: Defines coordinates that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMITAX	RID	HID	C	RID	HID	C			
ØMITAX	2	6	3	4	7	1			

Field	Contents
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component number (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Up to 12 coordinates may be omitted via this card.
3. Coordinates appearing on ØMITAX cards may not appear on MPCAX, SUPAX or SPCAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card PARAM Parameter

Description: Specifies values for parameters used in DMAP sequences (including rigid formats).

Format and Example :

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						
PARAM	IRES	1							

Field | Contents

N Parameter name (one to eight alphanumeric characters, the first of which is alphabetic)

V1, V2 Parameter value based on parameter type as follows:

Type	V1	V2
Integer	Integer	Blank
Real, single-precision	Real	Blank
BCD	BCD	Blank
Real, double-precision	Double-precision	Blank
Complex, single-precision	Real	Real
Complex, double-precision	Double-precision	Double-precision

Remarks:

1. Only parameters for which assigned values are allowed may be given values via the PARAM card. Section 5 describes parameters as used in DMAP.

2. See Section 3.1.5 for a list of parameters used in rigid formats that may be initialized by the user on PARAM cards.

Input Data Card PBAR Simple Beam Property

Description: Defines the properties of a simple beam (bar) which is used to create bar elements via the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PBAR	PID	MID	A	I1	I2	J	NSM		abc
PBAR	39	6	2.9		5.97				123
+bc	C1	C2	D1	D2	E1	E2	F1	F2	def
+23			2.0	4.0					
+ef	K1	K2	I12						

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of bar cross-section (Real)
I1, I2, I12	Area moments of inertia (Real)
J	Torsional constant (Real)
NSM	Nonstructural mass per unit length (Real)
K1, K2	Area factor for shear (Real)
Ci, Di, Ei, Fi	Stress recovery coefficients (Real)

Remarks:
1. For structural problems, PBAR cards may only reference MAT1 material cards.
2. See Section 1.3.2 for a discussion of bar element geometry.
3. For heat transfer problems, PBAR cards may only reference MAT4 or MAT5 material cards.

Input Data Card PCØNEAX Conical Shell Element Property

Description: Defines the properties of a conical shell element described on a CCØNEAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PCØNEAX	ID	MID1	T1	MID2	I	MID3	T2	NSM	+abc
PCØNEAX	2	4	1.0	6	16.3	8	2.1	0.5	+1
+abc	Z1	Z2	PHI1	PHI2	PHI3	PHI4	PHI5	PHI6	+def
+1	0.001	-0.002	23.6	42.9					+2
+def	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	PHI14	
+2									

Field	Contents
ID	Property identification number (Unique Integer > 0)
MIDi	Material identification number for membrane, bending, and transverse shear (Integer $\geq$ 0)
T1,T2	Membrane thickness and transverse shear thickness (Real > 0.0 if MIDi $\neq$ 0)
I	Moment of Inertia per unit width (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress recovery (Real)
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real)

Remarks:

1. This card is allowed if and only if a AXIC card is also present.
2. PCØNEAX cards may only reference MAT1 material cards.
3. If either MID1 = 0 or blank or T1 = 0.0 or blank, then both must be zero or blank.
4. If either MID2 = 0 or blank or I = 0.0 or blank, then both must be zero or blank.
5. If either MID3 = 0 or blank or T2 = 0.0 or blank, then both must be zero or blank.
6. A maximum of 14 azimuthal coordinates for stress recovery may be specified. An error will be detected if more than two (2) continuation cards appear.
7. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card PDAMP Scalar Damper Property

Description: Used to define the damping value of a scalar damper element which is defined by means of the CDAMP1 or CDAMP3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDAMP	PID	B	PID	B	PID	B	PID	B	
PDAMP	14	-2.3	2	6.1					

Field	Contents
PID	Property identification number (Integer > 0)
B	Value of scalar damper (Real)

Remarks:

1. This card defines a damper value. The user is cautioned to be careful when using negative damper values. Damper values are defined directly on the CDAMP2 and CDAMP4 cards. A structural viscous damper, CVISC, may also be used for geometric grid points.

2. Up to four damper properties may be defined on a single card.

3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card PDUMi Dummy Element Property

Description: Defines the properties of a dummy element ($1 \leq i \leq 9$). Referenced by the CDUMi card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDUMi	PID	MID	A1	A2			-etc.-		abc
PDUM3	108	2	2.4	9.6	1.E4	15.		3.5	ABC
+bc		-etc.-	AN						
+BC	5		2						

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A1...AN	Additional entries (Real or Integer)

Remarks: The additional entries are defined in the user written element routines.

Input Data Card PELAS Scalar Elastic Property

Description: Used to define the stiffness, damping coefficient, and stress coefficient of a scalar elastic element (spring) by means of the CELAS1 or CELAS3 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PELAS	PID	K	GE	S	PID	K	GE	S	
PELAS	7	4.29	0.06	7.92	27	2.17	0.0032		

Field	Contents
PID	Property identification number (Integer > 0)
K	Elastic property value (Real)
GE	Damping coefficient, g_e (Real)
S	Stress coefficient (Real)

Remarks:

1. The user is cautioned to be careful using negative spring values. (Values are defined directly on some of the CELASi card types.)
2. One or two elastic spring properties may be defined on a single card.
3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card PHBDY Property of Heat Boundary Element

Description: Defines the properties of the HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PHBDY	PID	MID	AF	E	ALPHA	R1	R2		
PHBDY	100	103	300	.79					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer $\geq$ 0 or blank), used for convective film coefficient and thermal capacity.
AF	Area factor (Real $\geq$ 0.0 or blank). Used only for HBDY types PØINT, LINE, and ELCYL.
E	Emissivity (0.0 $\leq$ Real $\leq$ 1.0 or blank). Used only for radiation calculations.
ALPHA	Absorbtivity (0.0 $\leq$ Real $\leq$ 1.0 or blank). Used only for thermal vector flux calculations, default value is E.
R1,R2	"Radii" of elliptic cylinder. Used for HBDY type "ELCYL". See the HBDY element description. (Real)

Remarks:

1. The referenced material Id must be on a MAT4 card. The card defines the convective film coefficient and thermal capacity per unit area. If no material is referenced the element convection and heat capacity are zero.

2. The area factor AF is used to determine the effective area. For a "PØINT", AF = area; for "LINE" or "ELCYL", AF = effective width where area = AF length. The effective area is automatically calculated for other HBDY types.

Input Data Card PLFACT Piecewise Linear Analysis Factor Definition Card

Description: Defines scale factors for Piecewise Linear Analysis loading.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLFACT	SID	B1	B2	B3	B4	B5	B6	B7	+abc
PLFACT	6	0.2	0.3	0.4	0.5	0.6	0.7	0.8	ABC
+abc	B8	B9	-etc.-						
+BC	0.9	1.0							

Field	Contents
SID	Unique set identification number (Integer > 0)
Bi	Loading factor (Real)

Remarks:

1. The remainder of the physical card containing the last entry must be null.
2. At any stage of the Piecewise Linear Analysis, the accumulated load is given by

$$\{P_i\} = B_i\{P\}$$

where {P} is the total load defined in the usual way.

Example: If it were desired to load the structure in ten equally spaced load increments then set

$$B_i = 0.1 \cdot i \quad ; \quad i = 1, 10$$

3. Normally, the B_i form a monotonically increasing sequence. A singular stiffness matrix will result if $B_i = B_{i-1}$.
4. At least two factors must be defined.
5. Piecewise Linear Analysis factor sets must be selected in the Case Control Deck (PLCØEFF=SID) to be used by NASTRAN.

Input Data Card PLØAD   Static Pressure Load

Description: Defines a static pressure load.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD	SID	P	G1	G2	G3	G4			
PLØAD	1	-4.0	16	32	11				

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure (Real)
G1,G2,G3,G4	Grid point identification numbers (Integer > 0; G4 may be zero)

Remarks:

1. Grid points must be unique and noncollinear.
2. If four grid points are given, four triangles are formed and half of P is applied to each one. For each triangle the direction is defined by

   $$+(\vec{r}_{12} \times \vec{r}_{13})$$

   where $\vec{r}_{ij}$ is the vector from Gi to Gj.
3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

Input Data Card PLØAD2 Pressure Load

Description: Defines a uniform static pressure load applied to two-dimensional elements. Only QUAD1, QUAD2, QDMEM, QDMEM1, QDMEM2, QDPLT, SHEAR, TRBSC, TRIA1, TRIA2, TRMEM, TRPLT or TWIST elements may have a pressure load applied to them via this card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD2	SID	P	EID	EID	EID	EID	EID	EID	
PLØAD2	21	-3.6		4	16		2		

Alternate Form

1	2	3	4	5	6	7	8	9	10
PLØAD2	SID	P	EID1	"THRU"	EID2				
PLØAD2	1	30.4	16	THRU	48				

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure value (Real)
EID, EID1, EID2	Element identification number (Integer > 0; EID1 < EID2)

Remarks:

1. EID must be 0 or blank for omitted entrys.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. At least one positive EID must be present on each PLØAD2 card.
4. If the alternate form is used, all elements EID1 thru EID2 must be two-dimensional.
5. The pressure load is computed for each element as if the grid points to which the element is connected were specified on a PLØAD card. The grid point sequence specified on the element connection card is assumed for the purpose of computing pressure loads.
6. All elements referenced must exist.

Input Data Card PLØTEL Dummy Element Definition

Description: Defines a dummy one-dimensional element for use in plotting. This element is not used in the model during any of the solution phases of a problem. It is used to simplify plotting of structures with large numbers of collinear grid points where the plotting of each one along with the elements connecting them would result in a confusing plot. The use of this "element" is entirely the responsibility of the user.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØTEL	EID	G1	G2		EID	G1	G2		
PLØTEL	29	35	16						

Field	Contents
EID	Element identification number (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 $\neq$ G2)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two PLØTEL elements may be defined on a single card.

Input Data Card PMASS Scalar Mass Property

Description: Used to define the mass value of a scalar mass element which is defined by means of the CMASS1 or CMASS3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PMASS	PID	M	PID	M	PID	M	PID	M	
PMASS	7	4.29	6	13.2					

Field	Contents
PID	Property identification number (Integer > 0)
M	Value of scalar mass (Real)

Remarks: 1. This card defines a mass value. The user is cautioned to be careful when using negative mass values. (Values are defined directly on some of the CMASSi card types.)

2. Up to four mass properties may be defined by this card.

3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

Input Data Card PØINTAX Conical Shell Point

Description: Defines the location of a point on an axisymmetric shell ring at which loads may be applied via the FØRCE or MØMENT cards and at which displacements may be requested. These points are not subject to constraints via MPCAX, SPCAX, or ØMITAX cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØINTAX	ID	RID	PHI						
PØINTAX	2	3	30.0						

Field	Contents
ID	Point identification number (Unique Integer > 0)
RID	Identification number of a RINGAX card (Integer > 0)
PHI	Azimuthal angle in degrees (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. PØINTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card PQDMEM Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM card. No bending properties are included.

Foramt and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PQDMEM cards must have unique property identification numbers.

2. One or two quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDMEM1 Isoparametric Quadrilateral Membrane Property

Description: Used to define the properties of an isoparametric quadrilateral membrane. Referenced by the CQDMEM1 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM1	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM1	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:
1. All PQDMEM1 cards must have unique property identification numbers.
2. One or two isoparametric quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDMEM2 Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM2 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM2	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM2	235	2	0.5	0.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PQDMEM2 cards must have unique property identification numbers.

2. One or two quadrilateral membrane properties may be defined on a single card.

Input Data Card PQDPLT Quadrilateral Plate Property

Description: Used to define the bending properties of a quadrilateral plate element. Referenced by the CQDPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PQDPLT	16	23	4.29	16	2.63	1.982	0.05	-0.05	

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer $\geq$ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequences defined on the CQDPLT card (Real)

Remarks:
1. All PQDPLT cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated for this element.

Input Data Card PQUAD1 General Quadrilateral Element Property

Description: Defines the properties of a general quadrilateral element of the structural model, including bending, membrane, and transverse shear effects. Referenced by the CQUAD1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PQUAD1	32	16	2.98	9	6.45	16	5.29	6.32	WXYZ1
+bc	Z1	Z2							
+XYZ1	0.09	-0.06							

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer $\geq$ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer $\geq$ 0)
I	Area moment of inertia per unit width (Real)
MID3	Material identification number for transverse shear (Integer $\geq$ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CQUAD1 card (Real)

Remarks:
1. All PQUAD1 cards must have unique property identification numbers.
2. If T3 is zero, the element is assumed to be rigid in transverse shear.
3. The membrane thickness, T1, is used to compute the structural mass for this element.

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Input Data Card PQUAD2 Homogeneous Quadrilateral Property

Decription : Defines the properties of a homogeneous quadrilateral element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CQUAD2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD2	PID	MID	T	NSM	PID	MID	T	NSM	
PQUAD2	32	16	2.98	9.0	45	16	5.29	6.32	

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real> 0.0)
NSM	Nonstructual mass per unit area (Real)

Remarks:

1. All PQUAD2 cards must have unique identification numbers.
2. The thickness used to compute membrane and transverse shear properties is T.
3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
4. Outer fiber distances of $\pm T/2$ are assumed.
5. One or two homogeneous quadrilateral properties may be defined on a single card.

Input Data Card PRESAX Conical Shell Pressure Load

Description: Defines the static pressure loading of a conical shell element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESAX	SID	P	RID1	RID2	PHI1	PHI2			
PRESAX	3	7.92	4	3	20.6	31.4			

Field	Contents
SID	Load set identification number (Integer > 0)
P	Pressure value (Real)
RID1, RID2	Ring identification numbers (see RINGAX card) (Integer > 0)
PHI1, PHI2	Azimuthal angles in degrees (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. Load sets must be selected in the Case Control Deck (LØAD=SID) in order to be used by NASTRAN.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card PRESPT Fluid Pressure Point

Description: Defines the location of pressure points in the fluid for recovery of pressure data.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
PRESPT	14		141	0.0			142	90.0	

Field	Contents
IDF	Fluid point (RINGFL) identification number (Integer > 0)
IDP	Unique pressure point identification number (Integer > 0)
ϕ	Azimuthal position on fluid point, referenced by IDF, in Fluid Coordinate System (Real)

Remarks:

1. This card is allowed only if an AXIF card is also present.
2. All pressure point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. The pressure points are used primarily for the identification of output data. They may also be used as points at which to measure pressure for input to control devices (see User's Manual, Section 1.7).
4. One, two or three pressure points may be defined per card.
5. Output requests for velocity and acceleration of these degrees of freedom will result in derivatives of pressure with respect to time.

Input Data Card PRØD Rod Property

Description: Defines the properties of a rod which is referenced by the CRØD card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRØD	PID	MID	A	J	C	NSM			
PRØD	17	23	42.6	17.92	4.236	0.5			

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient to determine torsional stress (Real)
NSM	Nonstructual mass per unit length (Real)

Remarks:

1. PRØD cards must all have unique property identification numbers.
2. For structural problems, PRØD cards may only reference MAT1 material cards.
3. For heat transfer problems, PRØD cards may only reference MAT4 or MAT5 cards.

Input Data Card PSHEAR Shear Panel Property

Description: Defines the elastic properties of a shear panel. Referenced by the CSHEAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PSHEAR	PID	MID	T	NSM	PID	MID	T	NSM	
PSHEAR	13	2	4.9	16.2	14	6	4.9	14.7	

Field	Contents
PID	Property identification number (Integer > C)
MID	Material identification number (Integer > 0)
T	Thickness of shear panel (Real $\neq$ 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:

1. All PSHEAR cards must have unique identification numbers.
2. PSHEAR cards may only reference MAT1 material cards.
3. One or two shear panel properties may be defined on a single card.

Input Data Card PTØRDRG Toroidal Ring Property

Description: Used to define membrane and flexure (bending) properties of a toroidal ring element. Referenced by the CTØRDRG card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTØRDRG	PID	MID	TM	TF	PID	MID	TM	TF	
PTØRDRG	2	4	0.1	0.15					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
TM	Thickness for membrane (Real > 0.0)
TF	Thickness for flexure (Real)

Remarks:

1. All PTØRDRG cards must have unique property identification numbers.
2. The material identification number MID must reference only a MAT1 or MAT3 card.
3. One or two toroidal ring properties may be defined on a single card.

Input Data Card PTRBSC Basic Bending Triangle Property

Description: Defines basic bending triangle (TRBSC) properties. Referenced by the CTRBSC card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRBSC	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRBSC	3	17	6.29	4	16.	1.982	0.05	-0.05	

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer $\geq$ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for shear computation, positive according to the right-hand sequence defined in the CTRBSC card (Real)

Remarks:
1. All PTRBSC cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated by this element.

Input Data Card PTRIA1 General Triangular Element Property

Description: Defines the properties of a general triangular element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CTRIA1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PTRIA1	32	16	2.98	9	6.45	16	5.29	6.32	QED
+bc	Z1	Z2							
+ED									

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer ≥ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer ≥ 0)
I	Area of moment of inertia per unit width (Real)
MID3	Bending material identification number for transverse shear (Integer ≥ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress calculations, positive according to the right-hand sequence defined on the CTRIA1 card (Real)

Remarks:
1. All PTRIA1 cards must have unique property identification numbers.
2. If T3 is zero, the element is assumed to be rigid in transverse shear.
3. The membrane thickness, T1, is used to compute the structural mass for this element.

Input Data Card PTRIA2 Homogeneous Triangular Element Property

Description: Defines the properties of a homogeneous triangular element of the structural model, including membrane, bending and transverse shear effects. Referenced by the CTRIA2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA2	PID	MID	T	NSM	PID	MID	T	NSM	
PTRIA2	2	16	3.92	14.7	6	16	2.96		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:
1. All PTRIA2 cards must have unique identification numbers.
2. The thickness used to compute the membrane and transverse shear properties is T.
3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
4. Outer fiber distances of $\pm T/2$ are assumed.
5. One or two homogeneous triangular element properties may be defined on a single card.

Input Data Card PTRMEM   Triangular Membrane Property

Description: Used to define the properties of a triangular membrane element. Referenced by the CTRMEM card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PTRMEM	17	23	4.25	0.2					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Membrane thickness (Real> 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks: 1. All PTRMEM cards must have unique property identification numbers.

2. One or two triangular membrane properties may be defined on a single card.

Input Data Card PTRPLT Triangular Plate Property

Description: Used to define the bending properties of a triangular plate element. Referenced by the CTRPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRPLT	17	26	4.29	16	3.9-4	2.634			

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CTRPLT card (Real)

Remarks:
1. All PTRPLT cards must have unique property identification numbers.
2. If T is zero, the element is assumed to be rigid in transverse shear.
3. No structural mass is generated by this element.

Input Data Card PTUBE Tube Property

Description: Defines the properties of a thin-walled cylindrical tube element. Referenced by the CTUBE card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTUBE	PID	MID	ØD	T	NSM				
PTUBE	2	6	6.29	0.25					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
ØD	Outside diameter of tube (Real > 0.0)
T	Thickness of tube (Real; T $\leq$ 1/2 ØD)
NSM	Nonstructural mass per unit length (Real)

Remarks:

1. If T is zero, a solid circular rod is assumed.
2. PTUBE cards must all have unique property identification numbers.
3. For structural problems, PTUBE cards may only reference MAT1 material cards.
4. For heat transfer problems, PTUBE cards may only reference MAT4 or MAT5 material cards.

Input Data Card PTWIST Twist Panel Property

Description: Defines the elastic properties of a twist panel element. Referenced by the CTWIST card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTWIST	PID	MID	T	NSM	PID	MID	T	NSM	
PTWIST	4	6	2.3	9.4	5	6	1.6		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of twist panel (Real $\neq$ 0.0)
NSM	Nonstructural mass per unit area (Real)

Remarks:
1. All PTWIST cards must have unique identification numbers.
2. PTWIST cards may only reference MAT1 material cards.
3. One or two twist panel properties may be defined on a single card.

Input Data Card PVISC Viscous Element Property

Description: Defines the viscous properties of a one-dimensional viscous element which is used to create viscous elements by means of the CVISC card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PVISC	PID	C1	C2		PID	C1	C2		
PVISC	3	6.2	3.94						

Field	Contents
PID	Property identification number (Integer > 0)
C1, C2	Viscous coefficients for extension and rotation (Real)

Remarks:

1. Used for both extensional and rotational viscous elements.
2. Has meaning for dynamics problems only.
3. Viscous properties are material independent; in particular, they are temperature-independent.
4. One or two viscous element properties may be defined on a single card.

Input Data Card QBDY1 Boundary Heat Flux Load

Description: Defines a uniform heat flux into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY1	SID	Q0	EID1	EID2	EID3	EID4	EID5	EID6	abc
QBDY1	109	1.-5	721						ABC
+bc	EID7	-etc.-							def
+BC									

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Heat flux into element (Real)
EIDi	HBDY elements (Integer > 0 or "THRU")

Remarks:

1. QBDY1 cards must be selected in Case Control (LØAD = SID) to be used in statics. The total power into an element is given by the equation:

$$P_{in} = (\text{Effective area}) \cdot Q0.$$

2. QBDY1 cards must be referenced on a TLØAD card for use in transient. The total power into an element is given by the equation:

$$P_{in(t)} = (\text{Effective area}) \cdot Q0 \cdot F(t-\tau),$$

where the function of time, $F(t-\tau)$, is specified on a TLØAD1 or TLØAD2 card.

3. Q0 is positive for heat input.

4. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

Input Data Card QBDY2 Boundary Heat Flux Load

Description: Defines grid point heat flux into an HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY2	SID	EID	Q01	Q02	Q03	Q04			
QBDY2	109	721	1.-5	1.-5	2.-5	2.-5			

Field	Contents
SID	Load set identification number (Integer > 0)
EID	Identification number of an HBDY element (Integer > 0)
Q0i	Heat flux at the i^{th} grid point on the referenced HBDY element (Real or blank)

Remarks:

1. QBDY2 cards must be selected in Case Control (LØAD = SID) to be used in statics. *The total power into each point, i, on an element is given by*

$$P_i = AREA_i \cdot Q0_i .$$

2. QBDY2 cards must be referenced on a TLØAD card for use in transient. All connected grid points will have the same time function, but may have individual delays. The total power into each point, i, or an element is given by

$$P_{i(t)} = AREA_i \cdot Q0_i \cdot F(t-\tau_i),$$

where $F(t-\tau_i)$ is a function of time specified on a TLØAD1 or TLØAD2 card.

3. $Q0_i$ is positive for heat flux input to the element.

NASTRAN DATA DECK

Input Data Card QHBDY Boundary Heat Flux Load

Description: Defines a uniform heat flux into a set of grid points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QHBDY	SID	FLAG	Q0	AF	G1	G2	G3	G4	
QHBDY	120	LINE	1.5+3	.75	13	15			

Field	Contents
SID	Load set identification number (Integer > 0)
FLAG	Type of area involved (must be one of the following "PØINT," "LINE," "REV," "AREA3," "AREA4")
Q0	Heat flux into an area (Real)
AF	Area factor depends on type (Real > 0.0 or blank)
G1,G2,G3,G4	Grid point identification of connected points (Integer > 0 or blank)

Remarks:

1. The heat flux applied to the area is transformed to loads on the points. These points need not correspond to an HBDY element.

2. The flux is applied to each point, i, by the equation

$$P_i = AREA_i \cdot Q0,$$

where Q0 is positive for heat input, and $AREA_i$ is the portion of the total area associated with point i.

3. In statics, the load is applied with the Case Control request: LØAD = SID. In dynamics, the load is applied by reference on a TLØADi data card. The load at each point will be multiplied by the function of time $F(t-\tau_i)$ defined on the TLØADi card. τ_i is the delay factor for each point.

4. The number of connected points for the five types are 1(PØINT), 2(LINE,REV), 3(AREA3), 4(AREA4). Any unused Gi entries must be on the right.

5. The area factor AF is used to determine the effective area for the PØINT and LINE types. It equals the area and the effective width, respectively. It is ignored for the other types, which have their area defined implicitly.

6. The type flag defines a surface in the same manner as the CHBDY data card. For physical descriptions of the geometry involved, see the CHBDY description.

NASTRAN DATA DECK

Input Data Card QVECT Thermal Vector Flux Load

Description: Defines thermal vector flux from a distant source into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVECT	SID	Q0	E1	E2	E3	EID1	EID2	EID3	abc
QVECT	333	1.-2	-1.0	0.0	0.0	721	722	723	ABC
+bc	EID4	EID5	-etc.-						def
+BC	724								

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Magnitude of thermal flux vector (Real)
E1,E2,E3	Vector components (in basic coordinate system) of the thermal vector flux (Real or Integer > 0). The total flux is given by Q = Q0{E1,E2,E3}
EID_i	Element identification numbers of HBDY elements irradiated by the distant source (Integer > 0)

Remarks:

1. For statics, the load set is selected in the Case Control Deck (LØAD = SID). The total power into an element is given by

$$P_{in} = -\alpha A(\bar{e}\cdot\bar{n})^{*}Q0,$$

where:

α = absorbtivity
A = area of HBDY element
$\bar{e}$ = vector of real numbers E1, E2, E3
$\bar{n}$ = positive normal vector of element, see CHBDY data card description
$(\bar{e}\cdot\bar{n})^{*}$ = 0 if the vector product is positive (i.e., the flux is coming from behind the element)

2. For transient analysis, the load set (SID) is selected by a TLØADi card which defines a load function of time. The total power into the element is given by

$$P_{\ell}(t) = -\alpha A(\bar{e}(t)\cdot\bar{n})^{*}Q0\ F(t-\tau),$$

where:

α,A, and $\bar{n}$ are the same as the statics case
$\bar{e}(t)$ = vector of three functions of time, which may be given on TABLEDi data cards. If E1, E2, or E3 is an integer, it is the table identification number. If E1, E2, or E3 is a real number, its value is used directly; if Ei is blank, its value is zero.
$F(t-\tau)$ is a function of time specified or referenced by the parent TLØAD1 or TLØAD2 card. The value τ is calculated for each loaded point.

QVECT (Cont.)

3. If the referenced HBDY element is of TYPE = ELCYL, the power input is an exact integration over the area exposed to the thermal flux vector.

4. If the referenced HBDY element is of TYPE = REV, the vector should be parallel to the basic z axis.

5. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

Input Data Card QVØL   Volume Heat Addition

Description: Defines a rate of internal heat generation in an element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVØL	SID	QV	EID1	EID2	EID3	EID4	EID5	EID6	abc
QVØL	333	1.+2	301	302	303	317	345	416	ABC

+bc	EID7	-etc.-							def
+BC	127								

-etc.-

Field	Contents
SID	Load set identification (Integer > 0)
QV	Power input per unit volume produced by a heat conduction element (Real)
EIDi	A list of heat conduction elements (Integer > 0 or BCD "THRU")

Remarks:

1. In statics, the load is applied with the case control request, LØAD = SID. The equivalent power into each grid point, i, connected to each element, is given by

$$P_i = QV \cdot VØL_i ,$$

where $VØL_i$ is the portion of the volume associated with point i and QV is positive for heat generation.

2. *In dynamics*, the load is requested by reference on a TLØADi data card. The equivalent power into each grid point i is

$$P_i = QV \cdot VØL_i \cdot F(t-\tau_i) ,$$

where $VØL_i$ is the portion of the volume associated with point i and $F(t-\tau_i)$ is the function of time defined by a TLØADi card. τ_i is the delay for each point i.

3. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element identification number, the BCD string "THRU" and the last element identification number. No subsequent data is allowed with this option.

Input Data Card RADLST List of Radiation Areas

Description: A list of HBDY identification numbers given in the same order as the columns of the RADMTX matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADLST	EID1	EID2	EID3	EID4	EID5	EID6	EID7	EID8	abc
RADLST	10	20	30	50	31	41	THRU	61	ABC
+bc	EID9	-etc.-							def
+BC	71								

-etc.-

Field	Contents
EIDi	The element identification numbers of the HBDY elements, given in the order that they appear in the RADMTX matrix (Integer > 0 or BCD "THRU")

Remarks:

1. This card is required if a RADMTX is defined.
2. Only one RADLST card string is allowed in a data deck.
3. If a group of the elements are sequential, any field except 2 and 9 may contain the BCD word "THRU". Element Id numbers will be generated for every integer between the value of the previous field and the value of the subsequent field. The values must increase, however.
4. Any element may be listed more than once. For instance, if both sides of a panel are radiating, each side may participate in a different part of the view factor matrix.

Input Data Card RADMTX Radiation Matrix

Description: Matrix of radiation exchange coefficients for nonlinear heat transfer analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADMTX	INDEX	Fi,i	Fi+1,i	Fi+2,i	Fi+3,i	Fi+4,i	Fi+5,i	Fi+6,i	abc
RADMTX	3	0.	9.3	17.2	16.1	.1	0.	6.2	ABC

+bc	Fi+7,i	-etc.-							def
+BC	6.2								

-etc.-

Field	Contents
INDEX	The column number of the matrix (Integer > 0)
Fi+k,i	The matrix values (Real), starting on the diagonal, continuing down the column. A group of zero's at the bottom of the column may be omitted. A blank field will end the column, which disallows imbedded blank fields.

Remarks:

1. The INDEX numbers go from 1 thru NA, where NA is the number of radiating areas.

2. The radiation exchange coefficient matrix is symmetric, and only the lower triangle is input. Column 1 is associated with the HBDY element first listed on the RADLST card, Column 2 for the next, etc. Null columns need not be entered.

3. $$P_i = \sum_{j=1}^{NA} F_{ij} \, q_j$$

   P_i = total irradiation into element i

   q_j = radiosity (per unit area) at j

   F_{ij} = radiation matrix (units of area)

4. A column may only be specified once.

Input Data Card RANDPS Power Spectral Density Specification

Description: Defines load set power spectral density factors for use in Random Analysis having the frequency dependent form

$$S_{jk}(F) = (X + iY)\ G(F)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDPS	SID	J	K	X	Y	TID			
RANDPS	5	3	7	2.0	2.5	4			

Field	Contents
SID	Random analysis set identification number (Integer > 0)
J	Subcase identification number of excited load set (Integer > 0)
K	Subcase identification number of applied load set (Integer $\geq$ 0; K $\geq$ J)
X,Y	Components of complex number (Real)
TID	Identification number of a TABRNDi card which defines G(F) (Integer $\geq$ 0)

Remarks:

1. If J = K, then Y must be 0.0.
2. For TID = 0, G(F) = 1.0.
3. Set identification numbers must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.
4. Only 20 unique sets may be defined. As many RANDPS cards as desired with the same SID may be input, however.
5. RANDPS can only reference subcases included within a single loop (change in direct matrix input is not allowed).

Input Data Card RANDT1 Autocorrelation Function Time Lag

Description: Defines time lag constants for use in random analysis autocorrelation function computation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDT1	SID	N	TO	TMAX					
RANDT1	5	10	3.2	9.6					

Field	Contents
SID	Random analysis set identification number (Integer > 0)
N	Number of time lag intervals (Integer > 0)
TO	Starting time lag (Real ≥ 0.0)
TMAX	Maximum time lag (Real > TO)

Remarks: 1. At least one RANDPS card must be present with the same set identification number.

2. The time lags defined on this card are given by

$$T_i = T_o + \frac{T_{max} - T_o}{N}(i - 1), \qquad i = 1, N + 1$$

3. Time lag sets must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.

BULK DATA DECK

Input Data Card RFØRCE Rotational Force

Description: Defines a static loading condition due to a centrifugal force field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RFØRCE	SID	G	CID	A	N1	N2	N3		
RFØRCE	2	5		-6.4	0.0	0.0	1.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer $\geq$ 0)
CID	Coordinate system defining rotation direction (Integer $\geq$ 0)
A	Scale factor for rotational velocity in revolutions per unit time (Real)
N1, N2, N3	Rectangular components of rotation direction vector (Real; $N1^2 + N2^2 + N3^2 > 0.0$) The vector defined will act at point G.

Remarks:

1. G = 0 means the basic coordinate system origin.
2. CID = 0 means the basic coordinate system.
3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
4. Rotational force sets can be combined with other static loads only by using the LØAD bulk data card.
5. The load vector generated by this card can be printed with an ØLØAD request in the Case Control Deck.

Input Data Card RINGAX Conical Shell Ring

Description: Defines a ring for conical shell problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGAX	ID		R	Z			PS		
RINGAX	3		2.0	-10.0			162		

Field	Contents
ID	Ring identification number (Integer > 0)
R	Ring radius (Real > 0.0)
Z	Ring axial location (Real)
PS	Permanent single-point constraints (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. The number of degrees of freedom defined is (6-PS)·H where H is the harmonic count and PS is the number of digits in field 8. (See AXIC card.)
3. RINGAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card RINGFL Axisymmetric Fluid Point

Description: Defines a circle (fluid point) in an axisymmetric fluid model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGFL	IDF	X1	X2	X3	IDF	X1	X2	X3	
RINGFL	3	1.0		30.0					

Field	Contents
IDF	Unique identification number of the fluid point (Integer, $0 < \text{IDF} < 10^5$)
X1,X2,X3	Coordinates of point in fluid coordinate system defined on AXIF card (Real; $X1 > 0.0$)

Remarks:
1. This card is allowed only if an AXIF card is also present.
2. All fluid point identification numbers must be unique with respect to other scalar, structural and fluid points.
3. X1, X2, X3 are (r, ϕ, z) for a cylindrical coordinate system and (ρ, θ, ϕ) for a spherical coordinate system. θ is in degrees. The value of ϕ must be blank or zero.
4. One or two fluid points may be defined per card.

Input Data Card RLØAD1 Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\left\{P(f)\right\} = \left\{A[C(f) + iD(f)]\, e^{i\{\theta - 2\pi f\tau\}}\right\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD1	SID	L	M	N	TC	TD			
RLØAD1	5	3	6	9	1	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE card set which defines θ (Integer $\geq$ 0)
TC	Set identification number of TABLEDi card which gives C(f) (Integer $\geq$ 0; TC + TD > 0)
TD	Set identification number of TABLEDi card which gives D(f) (Integer $\geq$ 0; TC + TD > 0)

Remarks:

1. If any of M, N, TC or TD are blank or zero, the corresponding τ, θ, C(f), or D(f) will be zero.
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD1 loads may be combined with RLØAD2 loads only by specification on a DLØAD card. That is, the SID on a RLØAD1 card may not be the same as that on a RLØAD2 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

Input Data Card RLØAD2   Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\left\{P(f)\right\} = \left\{AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}}\right\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD2	SID	L	M	N	TB	TP			
RLØAD2	5	3	6	21	7	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE card set which defines θ in degrees (Integer $\geq$ 0)
TB	Set identification number of TABLEDi card which gives B(f) (Integer > 0)
TP	Set identification number of TABLEDi card which gives $\phi(f)$ in degrees (Integer $\geq$ 0)

Remarks:
1. If any of M, N or TP are zero, the corresponding τ, θ or $\phi(f)$ will be zero.
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD2 loads may be combined with RLØAD1 loads only by specification on a DLØAD card. That is, the SID on a RLØAD2 card may not be the same as that on a RLØAD1 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

Input Data Card SECTAX Conical Shell Sector

Description: Defines a sector of a conical shell.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SECTAX	ID	RID	R	PHI1	PHI2				
SECTAX	1	2	3.0	30.0	40.0				

Field	Contents
ID	Sector identification number (Unique Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
R	Effective radius (Real)
PHI1, PHI2	Azimuthal limits of sector in degrees (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. SECTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

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NASTRAN DATA DECK

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Input Data Card SEQEP Extra Point Resequencing

Description: The purpose of this card is to allow the user to reidentify the formation sequence of the extra points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQEP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQEP	5392	15.6			2	1.9.2.6	3	2	

Field	Contents
ID	Extra point identification number (Integer > 0)
SEQID	Sequenced identification number (a special number described below)

Remarks:

1. ID is any extra point identification number which is to be reidentified for sequencing purposes. The sequence number is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.

2. If the user wishes to insert an extra point between two already existing grid, scalar and/or extra points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert extra point number 5392 between them by equivalencing it to, say, 15.6. All output referencing this point will refer to 5392.

3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No extra point ID may be referenced more than once.

4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.

5. From one to four extra points may be resequenced on a single card.

Input Data Card SEQGP Grid and Scalar Point Resequencing

Description: Used to order the grid points and user-supplied scalar points of the problem. The purpose of this card is to allow the user to reidentify the formation sequence of the grid and scalar points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQGP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQGP	5392	15.6			2	1.9.2.6	3	2	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
SEQID	Sequenced identification number (a specical number described below)

Remarks:

1. ID is any grid or scalar point identification number which is to be reidentified for sequencing purposes. The grid point sequence number (SEQID) is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.

2. If the user wishes to insert a grid point between two already existing grid points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert grid point number 5392 between them by equivalencing it to, say 15.6. All output referencing this point will refer to 5392.

3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No grid point ID may be referenced more than once.

4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.

5. From one to four grid or scalar points may be resequenced on a single card.

Input Data Card SLBDY Slot Boundary List

Description: Defines a list of slot points which lie on an interface between an axisymmetric fluid and a set of evenly spaced radial slots.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLBDY	RHØ	M	ID1	ID2	ID3	ID4	ID5	ID6	abc
SLBDY	0.002	6	16	17	18	25	20	21	+BDY

+bc	ID7	-etc.-							+def
+BDY	22								

- etc. -

Field	Contents
RHØ	Density of fluid at boundary (Real > 0.0, or "blank")
M	Number of slots (Integer ≥ 0, or "blank")
IDj	Identification numbers of GRIDS slot points at boundary with axisymmetric fluid cavity, j = 1,2,...,J (Integer > 0)

Remarks:

1. This card is allowed only if an AXSLØT card is also present.
2. If RHØ or M is "blank" the default value on the AXSLØT card is used. The effective value must not be zero for RHØ. If the effective value of M is zero, no matrices at the boundary will be generated.
3. The order of the list of points determines the topology of the boundary. The points are listed sequentially as one travels along the boundary in either direction. At least two points must be defined.
4. More than one logical boundary card may be used.

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Input Data Card SLØAD Static Scalar Load

Description: Used to apply static loads to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLØAD	SID	S	F	S	F	S	F		
SLØAD	16	2	5.9	17	-6.3	14	-2.93		

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scalar point identification number (Integer > 0)
F	Load value (Real)

Remarks:

1. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
2. Up to three scalar loads may be defined on a single card.

Input Data Card SPC *Single-Point Constraint*

Description : Defines sets of single-point constraints and enforced displacements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC	SID	G	C	D	G	C	D		
SPC	2	32	436	-2.6	5		+2.9		

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number (6 ≥ Integer ≥ 0; up to six unique such digits may be placed in the field with no imbedded blanks)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC1, ØMIT, ØMIT1 or SUPØRT card. D must be 0.0 for dynamics problems.
2. Single-point forces of constraint are recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. From one to twelve single-point constraints may be defined on a single card.
5. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.

Input Data Card SPC1 Single-Point Constraint

Description: Defines sets of single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	G1	G2	G3	G4	G5	G6	abc
SPC1	3	2	1	3	10	9	6	5	ABC

+bc	G7	G8	G9	-etc.-					
+BC	2	8							

Alternate Form

SPC1	SID	C	GID1	"THRU"	GID2				
SPC1	313	12456	6	THRU	32				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
C	Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null if point identification numbers are scalar points)
Gi, GIDi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. Note that enforced displacements are not available via this card. As many continuation cards as desired may appear when "THRU" is not used.

2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPC, ØMIT, ØMIT1, SUPØRT card.

3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.

4. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.

5. All grid points referenced by GID1 thru GID2 must exist.

Input Data Card SPCADD Single-Point Constraint

Description: Defines a single-point constraint set as a union of single-point constraint sets defined via SPC or SPC1 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
SPCADD	101	3	2	9	1				

+bc	S8	S9	-etc.-						

-etc.-

Field	Contents
SID	Identification number for new single-point constraint set (Integer > 0)
Si	Identification numbers of single-point constraint sets defined via SPC or SPC1 cards (Integer > 0; SID $\neq$ Si)

Remarks:

1. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
2. No Si may be the identification number of a single-point constraint set defined by another SPCADD card.
3. The Si values must be unique.

Input Data Card SPCAX Conical Shell Single-Point Constraint

Description: Defines sets of single-point constraints for conical shell coordinates. Enforced displacements may also be defined.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCAX	SID	RID	HID	C	V				
SPCAX	2	3	4	13	6.0				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer $\geq$ 0)
HID	Harmonic identification number (Integer $\geq$ 0)
C	Component identification number (any unique combination of the digits 1-6)
V	Enforced displacement value (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
3. Coordinates appearing on SPCAX cards may not appear on MPCAX, SUPAX or ØMITAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card SPØINT Scalar Point

Description: Defines scalar points of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
SPØINT	3	18	1	4	16	2			

Alternate Form

SPØINT	ID1	"THRU"	ID2						
SPØINT	5	THRU	649						

Field	Contents
ID,ID1,ID2	Scalar point identification number (Integer > 0; ID1 < ID2)

Remarks:

1. Scalar point defined by their appearance on a scalar connection card need not appear on a SPØINT card.
2. All scalar point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
3. This card is used primarily to define scalar points appearing in single or multipoint constraint equations but to which no scalar elements are connected.
4. If the alternate form is used, scalar points ID1 thru ID2 are defined.
5. For a discussion of scalar points, see Section 5.6 of the Theoretical Manual.

Input Data Card SUPAX Conical Shell Fictitious Support

Description: Defines conical shell coordinate at which the user desires determinate reactions to be applied to a free body during analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPAX	RID	HID	C	RID	HID	C			
SUPAX				4	3	2			

Field	Contents
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer $\geq$ 0)
C	Component number (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Up to 12 coordinates may appear on a single card.
3. Coordinates appearing on SUPAX cards may not appear on MPCAX, SPCAX or ØMITAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card SUPØRT Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied to a free body during analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPØRT	ID	C	ID	C	ID	C	ID	C	
SUPØRT	16	215							

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number (Zero or blank for scalar points; any unique combination of the digits 1-6 for grid points)

Remarks:

1. Coordinates defined on this card may not appear on single-point constraint cards (SPC, SPC1), on omit cards (ØMIT, ØMIT1) or in multipoint constraint equations as dependent coordinates (MPC).

2. From one to twenty-four support coordinates may be defined on a single card.

Input Data Card TABDMP1 Structural Damping Table

Description: Defines structural damping as a tabular function of frequency.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABDMP1	ID								abc
TABDMP1	3								ABC
+bc	f_1	g_1	f_2	g_2	f_3	g_3	f_4	g_4	
+BC	2.5	.01057	2.6	.01362	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
f_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
g_i	Damping value (Real)

Remarks:

1. The f_i must be in either ascending or descending order but not both.
2. Jumps ($f_i = f_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any f_i, g_i entry may be ignored by placing the BCD string "SKIP" in either of two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABDMP1 mnemonic infers the use of the algorithm

   $$\boxed{G = g_T(F)}$$

   where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.
7. Structural damping tables must be selected in the Case Control Deck (SDAMP=ID) to be used by NASTRAN.
8. Structural damping is used only in modal formulations of complex eigenvalue analysis, frequency response analysis, or transient response analysis.

Input Data Card TABLED1 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED1	ID								+abc
TABLED1	32								ABC

+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:
1. The x_i must be in either ascending or decending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLED2 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED2	ID	X1							+abc
TABLED2	15	-10.5							ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	1.0	-4.5	2.0	-4.2	2.0	2.8	7.0	6.5	DEF
+def	x_5	y_5	x_6	y_6	x_7	y_7	x_8	y_8	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or decending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED2 type tables, this algorithm is

$$\boxed{Y = y_T(X - X1)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X-X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLED3 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED3	ID	X1	X2						+abc
TABLED3	62	126.9	30.0						ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 $\neq$ 0.0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED3 type tables, this algorithm is

$$\boxed{Y = y_T\left(\frac{X - X1}{X2}\right)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLED4 Dynamic Load Tabular Function

Description: Defines coefficients of a power series for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED4	ID	X1	X2	X3	X4				+abc
TABLED4	28	0.0	1.0	0.0	100.				ABC

+abc	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field	Contents
ID	Table identification number (Integer > 0)
X1,X2,X3,X4	Table parameters (Real; X2 $\neq$ 0.0; X3 < X4)
A_i	Coefficient entries (Real)

Remarks: 1. At least one entry must be present.

2. The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".

3. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED4 type tables, this algorithm is

$$\boxed{Y = \sum_{i=0}^{N} A_i \left(\frac{X - X1}{X2}\right)^i}$$

where X is input to the table and Y is returned. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N + 1 entries in the table. There are no error returns from this table look-up procedure.

Input Data Card TABLEM1 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM1	ID								+abc
TABLEM1	32								ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM2 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM2	ID	X1							+abc
TABLEM2	15	-10.5							ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	1.0	-4.5	2.0	-4.5	2.0	2.8	7.0	6.5	DEF
+def	x_5	y_5	x_6	y_6	x_7	y_7	x_8	y_8	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. *Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two* fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM2 type tables, this algorithm is

$$\boxed{Y = Z\, y_T(X - X1)}$$

where X is input to the table, Y is returned and Z is supplied from the basic MATi card. The table look-up $y_T(x)$, $x = X - X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM3 Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM3	ID	X1	X2						+abc
TABLEM3	62	126.9	30.0						ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 $\neq$ 0.0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.
2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM3 type tables, this algorithm is

$$\boxed{Y = Z\, y_T\left(\frac{X - X1}{X2}\right)}$$

where X is input to the table, Y is returned and Z is supplied from basic MATi card. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TABLEM4 Material Property Table

Description: Defines coefficients of a power series for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM4	ID	X1	X2	X3	X4				+abc
TABLEM4	28	0.0	1.0	0.0	100.				ABC
+abc	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field	Contents
ID	Table identification number (Integer > 0)
X1,X2,X3,X4	Table parameters (Real; X2 $\neq$ 0.0; X3 < X4)
A_i	Coefficient entries (Real)

Remarks:
1. At least one entry must be present.
2. The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
3. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM4 type tables, this algorithm is

$$\boxed{Y = Z \sum_{i=0}^{N} A_i \left(\frac{X - X1}{X2}\right)^i}$$

where X is input to the table, Y is returned and Z is supplied from the basic MATi card. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N +1 entries in the table. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

Input Data Card TABLES1 Tabular Stress-Strain Function

Description: Defines a tabular stress-strain function for use in Piecewise Linear Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLES1	ID								+abc
TABLES1	32								ABC

+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
x_i, y_i	Tabular entries (Real)

Remarks:

1. The x_i must be in either ascending or descending order but not both.

2. For Piecewise Linear Analysis, the y_i numbers must form a nondecreasing sequence for an ascending x_i sequence and vice versa.

3. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.

4. At least two entries must be present.

5. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.

6. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".

7. Each TABLESi mnemonic infers the use of a specific algorithm. For TABLES1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

8. The table may have a zero slope only at its end.

Input Data Card TABRND1 Power Spectral Density Table

Description: Defines Power Spectral density as a tabular function of frequency for use in Random Analysis. Referenced on the RANDPS card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABRND1	ID								abc
TABRND1	3								ABC
+bc	f_1	g_1	f_2	g_2	f_3	g_3	f_4	g_4	def
+BC	2.5	.01057	2.6	.01362	ENDT				

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
f_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
g_i	Power Spectral Density (Real)

Remarks:

1. The f_i must be in either ascending or descending order but not both.
2. Jumps between two points $(f_i = f_{i+1})$ are allowed, but not at the end points.
3. At least two entries must be present.
4. Any f-g entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABRND1 mnemonic infers the use of the algorithm

$$\boxed{G = g_T(F)}$$

where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.

Input Data Card TEMP Grid Point Temperature Field

Description: Defines temperature at grid points for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMP	SID	G	T	G	T	G	T		
TEMP	3	94	316.2	49	219.8				

Field	Contents
SID	Temperature set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
T	Temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. From one to three grid point temperatures may be defined on a single card.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. If the element material is temperature dependent, its properties are evaluated at the average temperature.

5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPAX   Conical Shell Temperature

Description: Defines temperature sets for conical shell problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPAX	SID	RID	PHI	TEMP	SID	RID	PHI	TEMP	
TEMPAX	4	7	30.0	105.3					

Field	Contents
SID	Temperature set identification number (Integer > 0)
RID	Ring identification number (see RINGAX card) (Integer > 0)
PHI	Azimuthal angle in degrees (Real)
TEMP	Temperature (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. One or two temperatures may be defined on each card.
3. Temperature sets must be selected in the case Control Deck (TEMP=SID) to be used by NASTRAN.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPD Grid Point Temperature Field Default

Description: Defines a temperature default for all grid points of the structural model which have not been given a temperature on a TEMP card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPD	SID	T	SID	T	SID	T	SID	T	
TEMPD	1	216.3							

Field	Contents
SID	Temperature set identification number (Integer > 0)
T	Default temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. From one to four default temperatures may be defined on a single card.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. If the element material is temperature dependent, its properties are evaluated at the average temperature.

5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

NASTRAN DATA DECK

Input Data Card TEMPP1 Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane and combination elements (by an average temperature and a thermal gradient over the cross-section) for determination of:
1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP1	SID	EID1	$\bar{T}$	T'	T1	T2			+abc
TEMPP1	2	24	62.0	10.0	57.0	67.0			A1A

+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+1A	26	21	19	30					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+1A	1	THRU	10	30	THRU	61			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6, in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}$	Average temperature over the cross-section. Assumed constant over area (Real)
T'	Effective linear thermal gradient. Not used for membranes (Real)
T1, T2	Temperatures for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIA1, and PQUAD1 cards. T1 may be specified on the lower surface and T2 on the upper surface for the OUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. For a temperature field other than a constant gradient the "effective gradient" for a homogeneous plate is:

$$T' = \frac{1}{I}\int_{z} T(z)z\,dz$$

where I is the bending inertia, and z is the distance from the neutral surface in the positive normal direction.

(Continued)

TEMPP1 (Cont.)

5. The "average" temperature for a homogeneous plate is

$$\bar{T} = \frac{1}{\text{Volume}} \int_{\text{Volume}} T \, d\text{Volume}$$

6. If the element material is temperature dependent, its properties are evaluated at the average temperature $\bar{T}$.

7. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPP2 Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane, and combination elements by an average temperature and thermal moments for determination of:
1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP2	SID	EID1	$\bar{T}$	MX	MY	MXY	T1	T2	+abc
TEMPP2	2	36	68.8						XYZ

+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+YZ	400	1	2	5					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+YZ	37	THRU	312	315	THRU	320			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: a continuation card may have THRU in field 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}$	Average temperature over cross-section. Assumed constant over area (Real)
MX, MY, MXY	Resultant thermal moments per unit width in element coordinate system. Not used for membrane elements (Real)
T1, T2	Temperature for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIA1, and PQUAD1 cards. T1 may be specified on the lower surface and T2 on the upper surface for the QUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.

3. If thermal effects are requested all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

TEMPP2 (Cont.)

4. The thermal moments in the element coordinate system may be calculated from the formula:

$$\begin{Bmatrix} M_x \\ M_y \\ M_{xy} \end{Bmatrix} = -\int [G_e]\{\alpha_e\}T(z)z\,dz$$

where the integration is performed over the bending material properties in the element coordinate system.

$[G_e]$ - 3x3 elastic coefficient matrix

$\{\alpha_e\}$ - 3x1 material thermal expansion coefficients

$T(z)$ - temperature at z

z - distance from the neutral surface in the element coordinate system.

5. The temperature dependent material properties are evaluated at the average temperature T. If a property varies with depth, an effective value must be used which satisfies the desired elastic and stress relationships. The temperatures at the fibre distances may be changed to compensate for local differences in α_e and produce correct stresses.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPP3 Plate Element Temperature Field

Description: Defines a temperature field for homogeneous plate, membrane and combination elements (by a tabular description of the thermal field over the cross-section) for determination of:
1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP3	SID	EID1	Z0	T0	Z1	T1	Z2	T2	+abc
TEMPP3	17	39	0.0	32.9	2.0	43.4	2.5	45.0	XY1
+abc	Z3	T3	Z4	T4	Z5	T5	Z6	T6	+def
+Y1	3.0	60.0	4.0	90.0					XY2
+def	Z7	T7	Z8	T8	Z9	T9	Z10	T10	+ghi
+Y2									XY3
+ghi	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+jkl
+Y3	1	2	3	4	5	6	8	10	

-etc.-

Alternate Form of Continuation Card Number 3

+ghi	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+jkl
+Y3				1	THRU	10			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
Z0	Position of the bottom surface with respect to an arbitrary reference plane (Real)
Zi	Positions on cross-section from bottom to top of cross-section relative to the arbitrary reference plane. There must be an increasing sequence with the last nonzero value corresponding to the top surface (Real)
T0	Temperature at the bottom surface (Real)
Zi	Temperature at position Zi (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If the third (and succeeding) continuation card is present, EID1 and elements specified on the third (and succeeding) continuation cards are used. Elements must not be specified more than once.

3. The first and second continuation card must be present if a list of elements is to be used.

(Continued)

TEMPP3 (Cont.)

4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

5. If the element material is temperature dependent, its properties are evaluated at the average temperature over the depth which is calculated by the program using a linear distribution between points.

6. For stress recovery, the temperatures at the extreme points z_0 and z_N are assigned to the bottom surface and the top surface of the elements specified on either PTRIA2 or QUAD2 data card.

7. The data is limited to a maximum of eleven points on the temperature-depth profile.

8. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TEMPRB One-Dimensional Element Temperature Field

Description: Defines a temperature field for the BAR, RØD, TUBE, and CØNRØD elements for determination of:
1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPRB	SID	EID1	$\bar{T}$A	$\bar{T}$B	T'1a	T'1b	T'2a	T'2b	+abc
TEMPRB	200	1	68.0	23.0	0.0	28.0		2.5	AXY10
+abc	TCa	TDa	TEa	TFa	TCb	TDb	TEb	TFb	+def
+XY10	68.0	91.0	45.0		48.0	80.0	20.0		AXY20
+def	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+ghi
+XY20	9	10							

-etc.-

Alternate Form for Continuation Card Number 2

+def	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+ghi
+XY20	2	THRU	4	10	THRU	14			

-etc.-

Field	Contents
SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the second continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}$A, $\bar{T}$B	Average temperature over the area at end "a" and end"b" (Real)
T'ij	Effective linear gradient in direction i on end j (BAR only, Real)
Tij	Temperatures at point i as defined on the PBAR card(s) at end j. These data are used for stress recovery only (BAR only, Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If at least one nonzero or nonblank Tij is present, the point temperatures given are used for stress recovery. If no Tij values are given, linear temperature gradients are assumed for stresses.

3. If the second (and succeeding) continuation card is present, EID1 and elements specified on the second (and succeeding) continuation cards are used. Elements must not be specified more than once.

4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

TEMPRB (Cont.)

5. The effective thermal gradients in the element coordinate system for the BAR element are defined by the following integrals over the cross-section. For end "a" (end "b" is similar):

$$T'_{1a} = \frac{1}{I_1} \int_A T_a(y,z)y \, dA$$

$$T'_{2a} = \frac{1}{I_2} \int_A T_a(y,z)z \, dA$$

where $T_a(y,z)$ is the temperature at point y,z (in the element coordinate system) at end "a" of the BAR. See Section 1.3, Figure 1 for the element coordinate system: I_1 and I_2 are the moment of inertia about the z and y axis respectively. The temperatures are assumed to vary linearly along the length (x-axis). Note that if the temperature varies linearly over the cross-section then T'_{1a}, T'_{1b}, T'_{2a}, and T'_{2b} are the actual gradients.

6. If the element material is temperature dependent, the material properties are evaluated at the average temperature

$$\frac{\bar{T}_A + \bar{T}_B}{2}$$

7. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

Input Data Card TF   Dynamic Transfer Function

Description: 1. May be used to define a transfer function of the form

$$(B0 + B1p + B2p^2)u_d + \sum_i (A0(i) + A1(i)p + A2(i)p^2)u_i = 0$$

2. May be used as a means of direct matrix input.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TF	SID	GD	CD	B0	B1	B2			+abc
TF	1	2	3	4.0	5.0	6.0			+ABC
+abc	G(1)	C(1)	A0(1)	A1(1)	A2(1)				+def
+ABC	3	4	5.0	6.0	7.0				+DEF

(etc.)

Field	Contents
SID	Set identification number (Integer > 0)
GD,G(i)	Grid, scalar or extra point identification numbers (Integer > 0)
CD,C(i)	Component numbers (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
B0,B1,B2 A0(i),A1(i), A2(i)	Transfer function coefficients (Real)

Remarks: 1. The matrix elements defined by this card are added to the dynamic matrices for the problem.

2. Transfer Function sets must be selected in the Case Control Deck (TFL=SID) to be used by NASTRAN.

3. The constraint relation given above will hold only if no elements are connected to the dependent coordinate.

Input Data Card TIC   Transient Initial Condition

Description: Defines values for the initial conditions of coordinates used in Transient analysis. Both displacement and velocity values may be specified at independent coordinates of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TIC	SID	G	C	U0	V0				
TIC	1	3	2	5.0	-6.0				

Field	Contents
SID	Set identification number (Integer > 0)
G	Grid or scalar or extra point identification number (Integer > 0)
C	Component number (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
U0	Initial displacement value (Real)
V0	Initial velocity value (Real)

Remarks:
1. Transient initial condition sets must be selected in the Case Control Deck (IC=SID) to be used by NASTRAN.
2. If no TIC set is selected in Case Control Deck, all initial conditions are assumed zero.
3. Initial conditions for coordinates not specified on TIC cards will be assumed zero.
4. Initial conditions may be used only in direct formulation.

Input Data Card TLØAD1 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \{A\ F(t - \tau)\}$$

for use in transient response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD1	SID	L	M		TF				
TLØAD1	5	7	9		13				

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
TF	Identification number of TABLEDi card which gives $F(t - \tau)$ (Integer > 0)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD1 loads may be combined with TLØAD2 loads only by specification on a DLØAD card. That is, the SID on a TLØAD1 card may not be the same as that on a TLØAD2 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.
6. Field 3 may reference sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is used, the referenced QVECT data card may also contain references to functions of time, and therefore A may be a function of time.

Input Data Card TLØAD2 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \begin{cases} \{0\}, & \tilde{t} < 0 \text{ or } \tilde{t} > T2 - T1 \\ \left\{A\, \tilde{t}^{B}\, e^{C\tilde{t}} \cos(2\pi F\tilde{t} + P)\right\}, & 0 \leq \tilde{t} \leq T2 - T1 \end{cases}$$

for use in transient response problems where $\tilde{t} = t - T1 - \tau$.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD2	SID	L	M		T1	T2	F	P	abc
TLØAD2	4	10	7		2.1	4.7	12.0	30.0	+12
+bc	C	B							
+12	2.0	3.0							

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
T1	Time constant (Real $\geq$ 0.0)
T2	Time constant (Real, T2 > T1)
F	Frequency in cycles per unit time (Real $\geq$ 0.0)
P	Phase angle in degrees (Real)
C	Exponential coefficient (Real)
B	Growth coefficient (Real)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD2 loads may be combined with TLØAD1 loads <u>only</u> by specification on a DLØAD card. That is, the SID on a TLØAD2 card may <u>not</u> be the same as that on a TLØAD1 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.

TLØAD2 (cont.)

6. Field 3 may reference load sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.

7. If the heat transfer option is being used, the referenced QVECT load card may also contain references to functions of time, and therefore A may be a function of time.

Input Data Card TSTEP Transient Time Step

Description: Defines time step intervals at which solution will be generated and output in Transient Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TSTEP	SID	N(1)	DT(1)	NØ(1)					+abc
TSTEP	2	10	.001	5					+ABC

1	2	3	4	5	6	7	8	9	10
+abc		N(2)	DT(2)	NØ(2)					+def
+ABC		9	0.01	1					+DEF

(etc.)

Field	Contents
SID	Set identification number (Integer > 0)
N(i)	Number of time steps of value DT(i) (Integer $\geq$ 2)
DT(i)	Time increment (Real > 0.0)
NØ(i)	Skip factor for output (Every NØ(i)$^{\underline{th}}$ step will be saved for output) (Integer > 0)

Remarks: TSTEP cards must be selected in the Case Control Deck (TSTEP=SID) in order to be used by NASTRAN.

2.5 USER'S MASTER FILE

As a means of aiding the user in handling the large (several boxes of cards) Bulk Data Decks which are typical of NASTRAN problems, the User's Master File is provided for storage of many Bulk Data Decks on a single tape. There are many advantages to using a Master File. For a problem that several investigators are concurrently studying, the User's Master File provides a convenient common source of data. Standardization is easy to impose since there can be only one legitimate structural model deck for any given problem. When various parts of a structure are being analyzed separately, they may all be placed on the same User's Master File for ease of use. Errors due to card handling equipment (and people!) are sharply reduced since a several box input deck is reduced to a few cards. Finally, the convenience to the user in submitting jobs should be emphasized (run decks can be hand-carried!).

2.5.1 Use of User's Master File

Functionally, the User's Master File exhibits all of the properties of an Old Problem Tape (ØPTP) which would result if a job were terminated after the NASTRAN preface; only the control cards used are different. Thus the User's Master File (UMF) becomes an alternate source of bulk data input to NASTRAN which may be modified in identically the same way as bulk data is changed during a modified restart. Since the UMF is used as an alternate ØPTP functionally, only one or the other may appear in a run. The UMF, then, is used only for an initial run and may not be used in conjunction with a restart. The checkpoint feature may be used with a UMF run, however, and the resulting New Problem Tape (NPTP) may be used as an ØPTP in a subsequent restart.

In describing the use of the User's Master File, the UMF control cards will be contrasted with their ØPTP counterparts. In place of the setup card for the ØPTP tape (see Chapter 5 of the Programmer's Manual for a discussion of these machine and installation dependent NASTRAN driver control cards), use a setup card for the selected UMF tape. In place of the restart dictionary in the Executive Control Deck, use the card

$$\text{UMF} \quad k_1, k_2$$

described in Section 2.2.1, which selects Bulk Data Deck k_2 from UMF tape k_1 to use in the current execution.

2.5.2 Using the User's Master File editor

To assist the NASTRAN user in creating the maintaining User's Master Files, an auxiliary NASTRAN preface module, the User's Master File Editor, is provided. The functions performed by the Editor are:

1. Create a New User's Master File (NUMF) from Bulk Data Decks supplied by the user.
2. List and/or punch Bulk Data Decks from an already existing UMF.
3. Edit Bulk Data Decks (which may be modified) from an old UMF onto a new UMF.

Bulk Data Decks must be acceptable to the NASTRAN preface (XSØRT and IFP) to be accepted by the Editor.

The executive control card that causes NASTRAN to execute as the User's Master File Editor is UMFEDIT. When in the Editor mode, NASTRAN executes only the preface. A separate run is required to use a User's Master File generated by the Editor. Preface module UMFEDT, which is where the User's Master File Editor actions occur, reads data cards from the System Input Stream which are used to control Editor activity. Some of these data cards precede the Bulk Data Deck being processed while others follow. The remainder of this section will be devoted to describing these cards and the action caused by them. Section 2.5.3 gives some rules to be followed when making up data cards for the Editor. Several examples will then be given in Section 2.5.4 to illustrate the functions performed by the User's Master File Editor.

Table 1 shows the Editor data cards and describes the action taken for each one. Three classes are described, depending on the tapes used. The cards are free-field format as are the executive control cards and case control cards previously described. The symbolic quantities tid and pid are arbitrarily selected integers chosen by the user who causes the User's Master File to be created.

When a New User's Master File (NUMF) is created, the User's Master File Editor (UMFEDIT) punches the Executive Control cards that are needed to read the decks from the newly created master file. The UMFEDIT punches one UMF Executive Control card for each Bulk Data Deck that is written on the NUMF.

2.5.3 Rules for the User's Master File Editor

1. The tape identification number, tid, and the problem identification number, pid, are positive integers selected by the user. The only exception to this is that pid may be zero if the UMF card is being used only to specify a value for tid or to indicate a new deck rather than an alter set.

2. The tape identification number, tid, must be the same for all decks on a single UMF.

3. Only one pass is made while either reading the UMF or writing the NUMF. Sequential processing requests are thereby required. This means that the problem identification numbers must form an increasing sequence corresponding to the order of the decks.

4. A corollary to 2 is that a deck to be inserted between two decks on an existing UMF must be given a problem identification number whose value "lies between" the values of the problem identification numbers for the two UMF decks. Thus, an initial numbering sequence such as 10, 20, 30, ... is recommended.

5. Most NASTRAN users develop the habit of "storing" data cards not needed for a given run behind the ENDDATA card where they are normally ignored. This must not be done when using the Editor since it reads data from this position. Data cards following the FINIS card are ignored, however.

2.5.4 Examples of User's Master File Editor Usage

Several examples of User's Master File Editor usage are given in this section. The user is well-advised to study these examples both from the standpoint of understanding the functioning of the Editor and from the standpoint of learning how to use this NASTRAN feature. A symbolic representation of the contents of the UMF and/or NUMF used in each example is given along with an explanation of specific items of interest. These examples illustrate all of the capability of the User's Master File Editor.

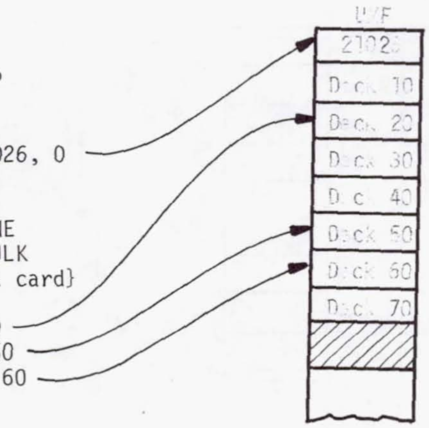
Example 1. Create a User's Master File

```
ID  A,B
TIME 1
APP DMAP
BEGIN
END
UMFEDIT
CEND
TITLE = USER'S MASTER FILE CØNTAINS
LABEL = PRØBLEMS 50, 60, ..., 80
ECHØ = BØTH
MAXLINES=50000
BEGIN BULK )
    .       }
    .       }  1st Bulk Data Deck
    .       }
ENDDATA     )
NUMF  21026, 50
BEGIN BULK )
    .       }
    .       }  2nd Bulk Data Deck
    .       }
ENDDATA     )
NUMF  21026, 60
    .
    .
    .
    .
    .
BEGIN BULK )
    .       }
    .       }  Last Bulk Data Deck
    .       }
ENDDATA     )
NUMF  21026, 80
FINIS
```

Notes:
1. A tape must be set up for NASTRAN file NUMF.
2. A tape must not be set up for NASTRAN file UMF.
3. The DMAP sequence will not be used but must appear in the Executive Control Deck.
4. ECHØ = BØTH is recommended since the unsorted Bulk Data Deck is available only during the run used to create the User's Master File. The sorted echo is needed in order to make alterations to the bulk data when using the User's Master File in a NASTRAN run.
5. Note that the tape identification number, tid, is the same on all of the NUMF cards.
6. Note that the problem identification numbers, pid, are increasing according to the data deck order.

Example 2. List and/or punch selected decks from a User's Master File

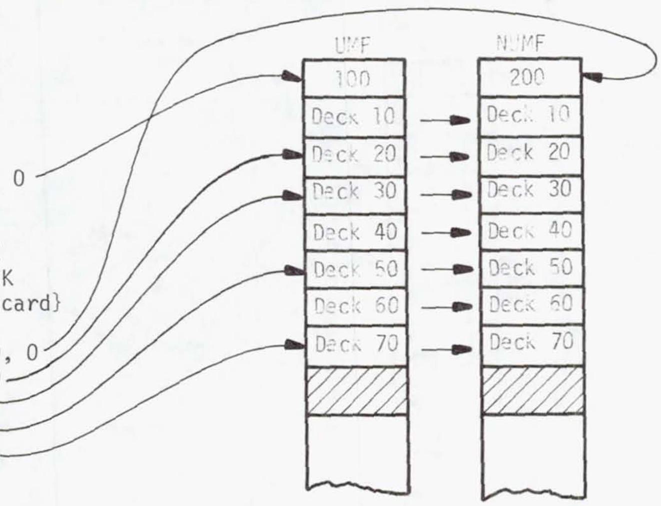
```
ID  A,B
TIME 1
APP DMAP
BEGIN
END
UMF  21026, 0
UMFEDIT
CEND
ECHØ=NØNE
BEGIN BULK
  {blank card}
ENDDATA
LIST  20
PUNCH  50
PUNPRT  60
FINIS
```



Notes:
1. A tape containing the proper User's Master File must be set up on NASTRAN file UMF.
2. A tape must not be set up for NASTRAN file NUMF.
3. The DMAP sequence will not be used but must appear in the Executive Control Deck.
4. The dummy Bulk Data Deck consisting of a single blank card will not be used but must appear.
5. ECHØ = NØNE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.
6. The zero value of pid on the UMF card is required since only tid is being used in this application.
7. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.
8. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20 and 60; decks 50 and 60 will be punched.

<u>Example 3. Copy a User's Master File while listing and/or punching selected decks.</u>

```
ID  A,B
TIME 5
APP DMAP
BEGIN
END
UMF  100, 0
UMFEDIT
CEND
ECHØ=NØNE
BEGIN BULK
  {blank card}
ENDDATA
NUMF  200, 0
PUNPRT 20
LIST 30
LIST 50
PUNCH 70
FINIS
```



Notes:

1. A tape containing the User's Master File to be copied <u>must</u> be set up on NASTRAN file UMF.

2. A tape <u>must</u> be set up on NASTRAN file NUMF.

3. The DMAP sequence is not used but <u>must appear</u> in the Executive Control Deck.

4. The dummy Bulk Data Deck consisting of a single blank card will not be used but <u>must appear</u>.

5. ECHØ = NØNE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.

6. The zero value of pid on the UMF card is required since only tid is being used in this application.

7. The zero value of pid on the NUMF card is not used. This card is used to specify tid for the NUMF. If the NUMF card were absent, the same tid would be put on the NUMF as existed on the UMF.

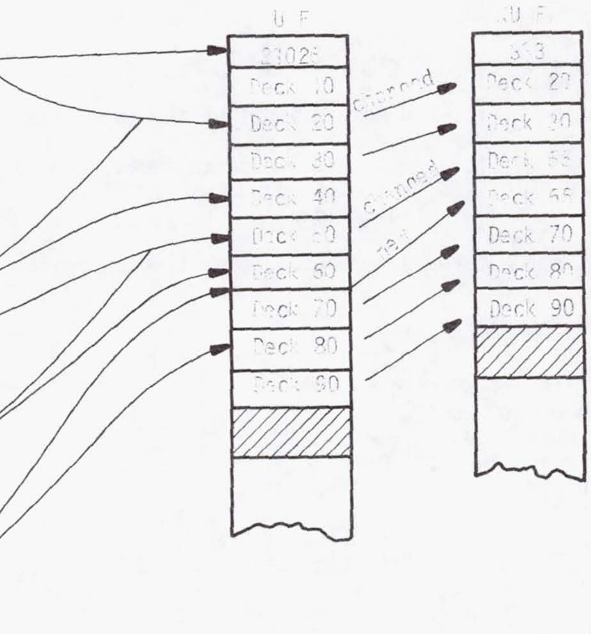
8. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.

9. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20, 30, and 50; decks 20 and 70 will be punched.

10. All of the decks contained on the UMF will be copied onto the NUMF tape. The tape identification number will be different as explained in note 7.

Example 4. Edit a User's Master File

```
ID A,B
TIME 5
APP DMAP
BEGIN
END
UMF  21026, 20
UMFEDIT
CEND
TITLE = MØDIFICATIØN ØF
SUBTITLE = DECKS 20 AND 50
ECHØ = BØTH
BEGIN BULK
  {alter cards for Deck 20}
ENDDATA
NUMF  333, 20
REMØVE 40
UMF  21026, 50
BEGIN BULK
  {alter cards for Deck 50}
ENDDATA
NUMF  333, 55
REMØVE 60
UMF  21026, 0
BEGIN BULK
  {Deck 65}
ENDDATA
NUMF 333, 65
LIST 80
FINIS
```



Notes:

1. A tape containing the User's Master File to be edited must be set up on NASTRAN file UMF.

2. A tape must be set up on NASTRAN file NUMF.

3. The DMAP sequence is not used but must appear in the Executive Control Deck.

4. ECHØ = BØTH is recommended since the alter cards are available only during the run used to perform the edit. The sorted echo is needed for those decks being altered in order to make further alterations to the bulk data when using the newly created User's Master File in a NASTRAN run. Decks not being altered will not be echoed as a result of the ECHØ = BØTH card. Such decks may be echoed as they are copied as shown in the example for Deck 80.

5. The pid values must form an increasing sequence.

6. The requests in the above example will cause listings to be generated for deck 80; no decks will be punched.

7. Decks 30, 70, 80, and 90 will be copied onto the NUMF with no changes.

8. Decks 10, 40, and 60 will be removed (i.e., not copied onto the NUMF).

9. Decks 20 and 50 will be modified. In addition the problem identification number of Deck 50 will be changed to 55.

10. Deck 65 will be added.

11. Deck 10 is removed because it appears prior to the first call to the Editor. This may be avoided by using a pid of zero and a dummy Bulk Data Deck as shown in Example 3.

Table 1. User's Master File Editor Control Card Actions.

I. UMF Only is Present

- A. FINIS
  1. Terminate run.
- B. BEGIN BULK (Not Allowed)
- C. REMØVE pid (Not Allowed)
- D. LIST pid
  1. Skip UMF forward to pid and list the Bulk Data Deck on the printer.
- E. PUNCH pid
  1. Skip UMF forward to pid and punch the Bulk Data Deck on the punch.
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid (Not Allowed)
- H. PUNPRT pid
  1. Skip UMF forward to pid and then list and punch the Bulk Data Deck.

II. NUMF Only is Present

- A. FINIS
  1. Write end-of-file on NUMF.
  2. Terminate run.
- B. BEGIN BULK
  1. Process the next Bulk Data Deck.
- C. REMØVE pid (Not Allowed)
- D. LIST pid (Not Allowed)
- E. PUNCH pid (Not Allowed)
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid
  1. If first entry to Editor, write tape identification file on NUMF.
  2. Add preceeding Bulk Data Deck to NUMF and punch UMF card for use with UMF.
- H. PUNPRT pid (Not Allowed)

III. Both UMF and NUMF are Present

- A. FINIS
  1. Copy any remaining Bulk Data Decks from UMF to NUMF.
  2. Write end-of-file on NUMF.
  3. Terminate run.
- B. BEGIN BULK
  1. Process the next Bulk Data Deck which may be a new deck or a modified deck from the UMF.
- C. REMØVE pid
  1. Copy UMF onto NUMF up to indicated deck.
  2. Skip indicated deck on UMF.
- D. LIST pid
  1. Copy UMF onto NUMF through indicated deck.
  2. List indicated Bulk Data Deck on printer.
- E. PUNCH pid
  1. Copy UMF onto NUMF through indicated deck.
  2. Punch indicated Bulk Data Deck on printer.
- F. UMF tid, pid
  1. Copy UMF onto NUMF up to indicated deck. (Must be immediately followed by BEGIN BULK card.)
- G. NUMF tid, pid
  1. If first entry to Editor, write tape identification file on NUMF.
  2. Copy UMF onto NUMF up to deck with identification greater than pid.
  3. Add preceeding Bulk Data Deck to NUMF and punch UMF card for use with UMF.
- H. PUNPRT pid
  1. Copy UMF onto NUMF through indicated deck.
  2. List indicated Bulk Data Deck on printer.
  3. Punch indicated Bulk Data Deck on punch.

2.6 USER GENERATED INPUT

It may happen that a user will want to take a problem previously run on another program and run it using NASTRAN. In many instances, this provides the user with the quickest means of familiarizing himself with NASTRAN since he is running a problem which he understands intimately. Also, he may wish to extend his analysis of some previously analyzed problem into regions which previous programs would not allow. In either event, he is faced with the problem of Input Data conversion.

The simplest way to convert structural model data is to write a small FØRTRAN (or other language) program to read in the data cards composing the input data deck for the previous program and punch a new NASTRAN Bulk Data Deck. Usually, the information is in a one to one correspondence, and this procedure is quite straight forward, requiring only a minimal knowledge of programming. While a large deck of cards may result, by using the User's Master File feature described in Section 2.5, the amount of large deck handling may be minimized.

2.6.1 Utility Module INPUT Usage

NASTRAN has implemented one user utility module within its existing structure.

2.6.1.1 General

1. INPUT allows the user of NASTRAN to generate the majority of the bulk data cards for a number of selected test problems without having to actually input the physical cards into the Bulk Data Deck.

2. The test problems for which partial data are generated by INPUT are:

   a. N x N Laplace Network from scalar elements

   b. W x L Rectangular Frame from BAR elements or RØD elements

   c. W x L Rectangular Array of QUAD1 elements

   d. W x L Rectangular Array of TRIA1 elements

   e. N - segment string from scalar elements

   f. N - cell beam made from BAR elements

   g. N - scalar point full matrix with optional unit loading

   These problem types are described separately in section 2.6.1.2.

3. To use INPUT the following alter deck must be used:

```
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT GEØM1,GEØM2,---,GEØM5/G1,G2,---,G5/C,N,a/C,N,b/C,N,c $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE----/ G5,GEØM5 $
ENDALTER
```

The specific data blocks that need be included depend on the particular problem as do the parameter values. Examples for each problem type will be given.

4. Data cards are read by INPUT from the System Input File using FØRTRAN I/Ø, each card containing up to 10 eight column fields. Remember to right-justify this data. The required data are described in each problem type description.

5. The INPUT data card(s) follow the ENDDATA card.

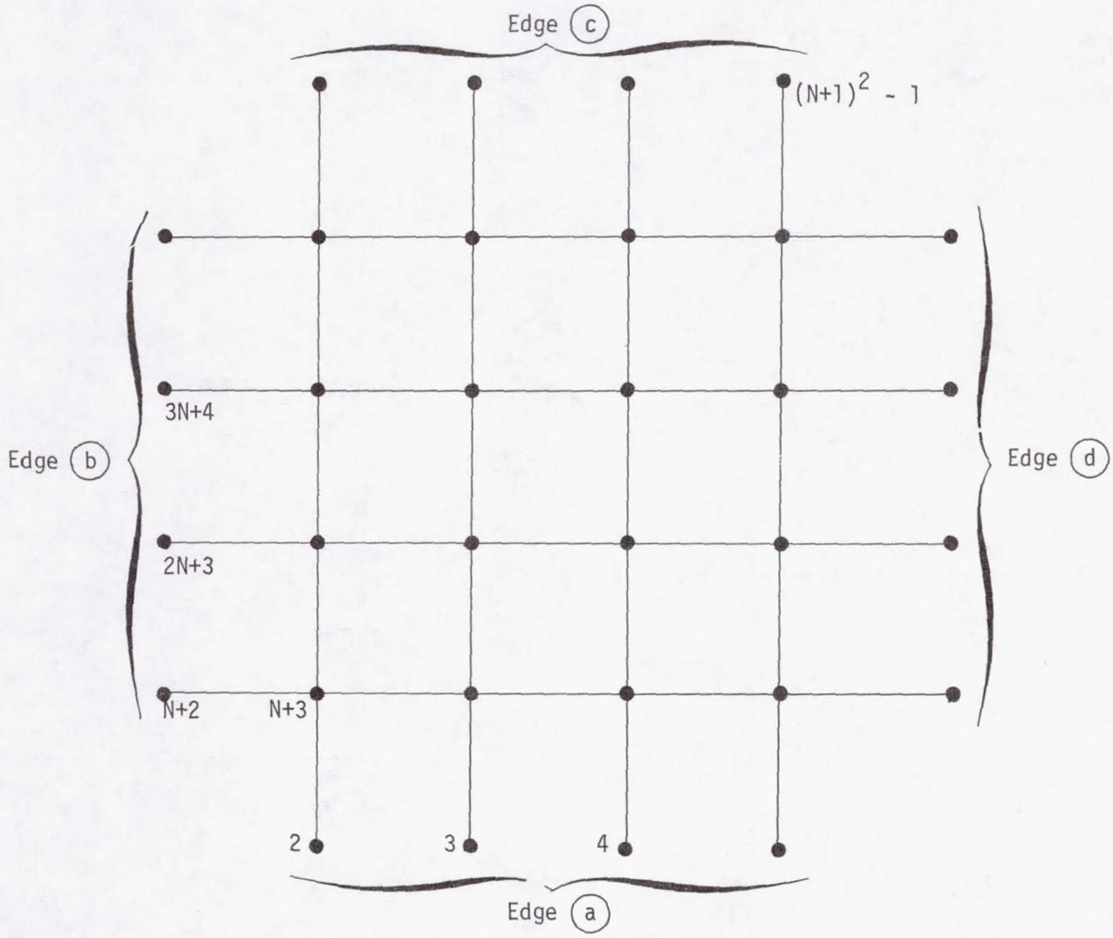
6. Several sample problems were run as part of checkout. The input for these runs are available as examples of INPUT usage.

7. Restart tables are not effective with respect to "cards" generated by INPUT since the preface is unaware of their existance.

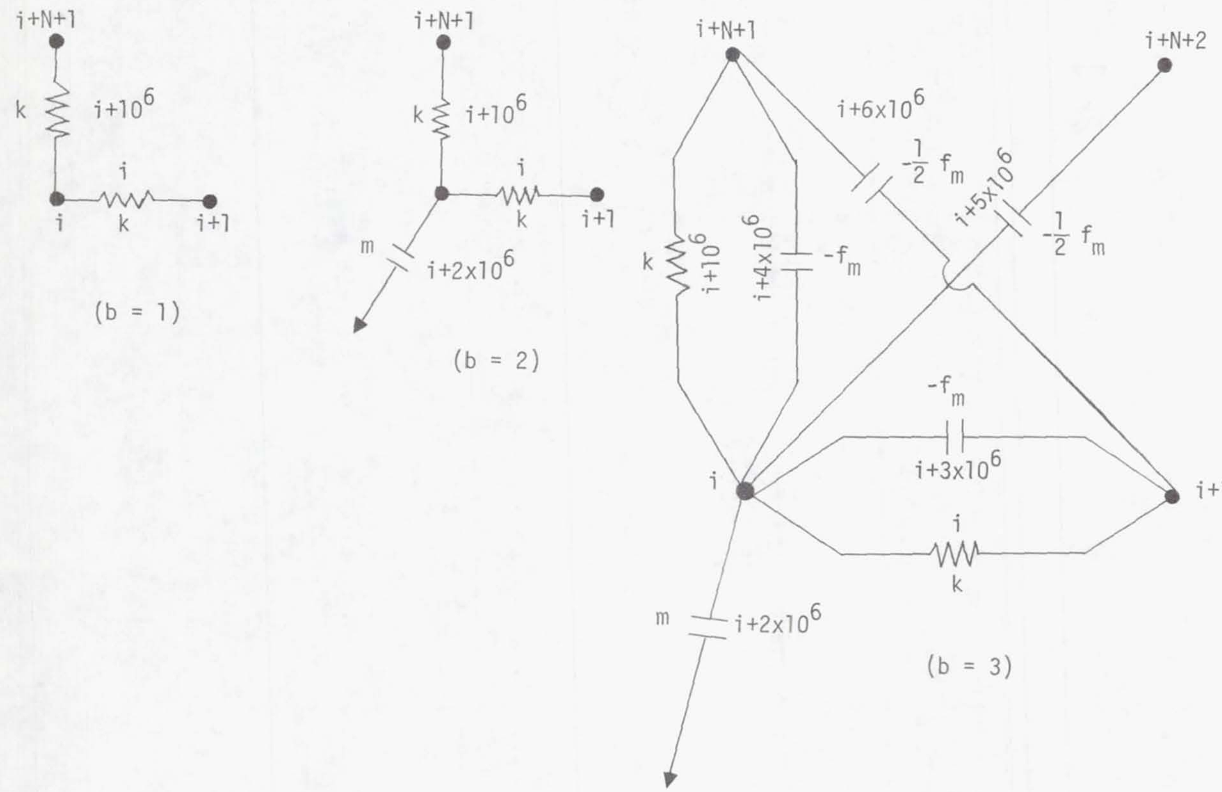
2.6.1.2 Problems Handled by INPUT

1. Laplace Circuit (a=1, c is not used)

INPUT generates CELAS4, SPC (for b=1), and CMASS4 (for b =2,3) cards for the circuit shown.



The scalar point id's are 1 through $(N+1)^2$ except for 1, N+1, N(N+1)+1, and $(N+1)^2$. For b = 2 or 3, all edge points are replaced with ground. The scalar elements generated are shown below for each value of b for a typical cell. Elements between edge points are not generated.



a. Data Card

1	N	(I8)	N^2 = no. of cells
2	k	(E8.0)	Spring stiffness
3	U	(E8.0)	Enforced displacement along edge (b) (b = 1)
3	m	(E8.0)	Mass (b = 2,3)
4	f	(E8.0)	Coupling fraction (b = 3 only)

b. Options

(1) (b = 1)

Use statics (Rigid Format D-1) to solve $\nabla^2 u = 0$ with boundary conditions u = 0 along (a), (c) and (d), u = U along (b).
G2 and G4 are both used. No masses are generated.

(2) (b = 2) No mass coupling

Use real eigenvalue analysis (Rigid Format D-3) to obtain the eigenvalues of a square membrane ($\nabla^2 u = \frac{\partial^2 u}{\partial t^2}$) where the theoretical solutions for $N \to \infty$ are given by

$$f_{ij} = \frac{1}{N}\{i^2 + j^2\}^{1/2} \; ; \quad i,j = 1,2,---$$

U is ignored. Only G2 is used. Diagonal masses only are generated.

(3) (b = 3) Mass coupling

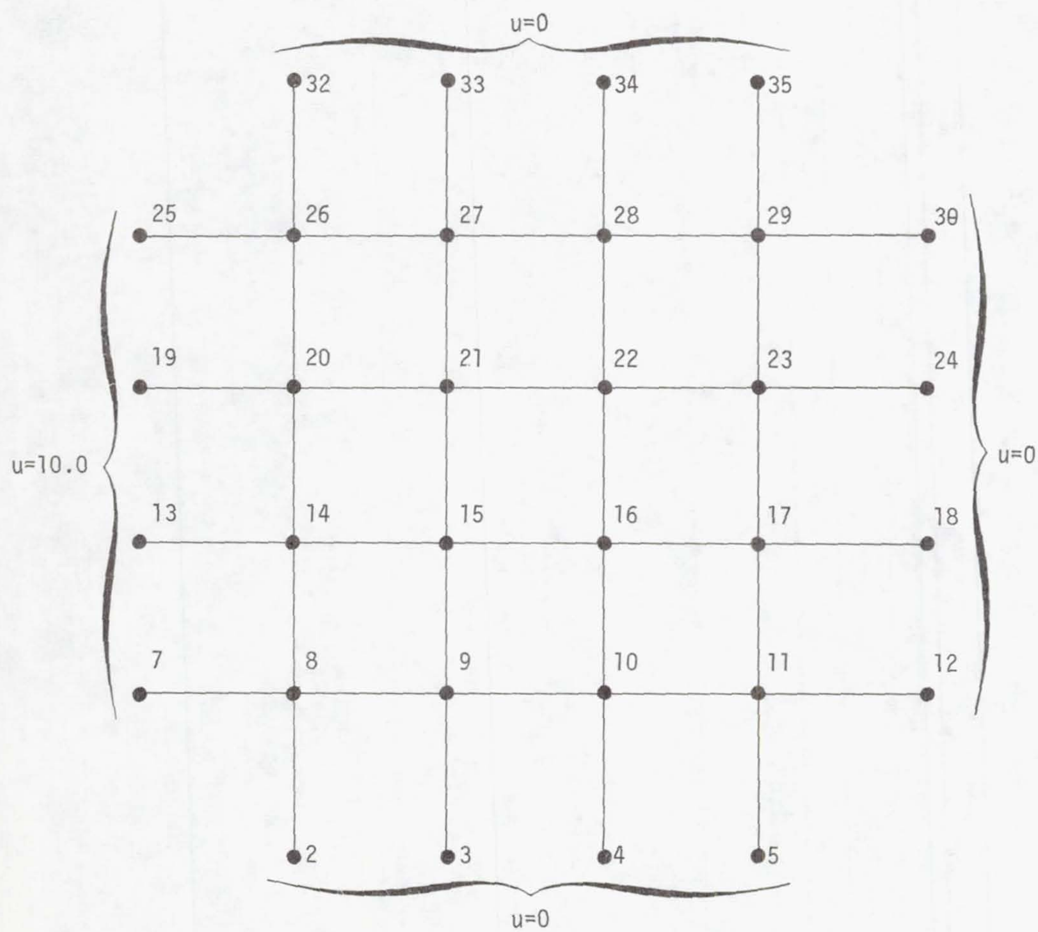
Same as (2) where the diagonal masses are m. The horizontal and vertical masses are $-f_m$; the cross diagonal masses are $-\frac{1}{2} f_m$.

c. Notes

(1) For b = 1, SPC = 1000+N must be selected in Case Control Deck.

NASTRAN DATA DECK

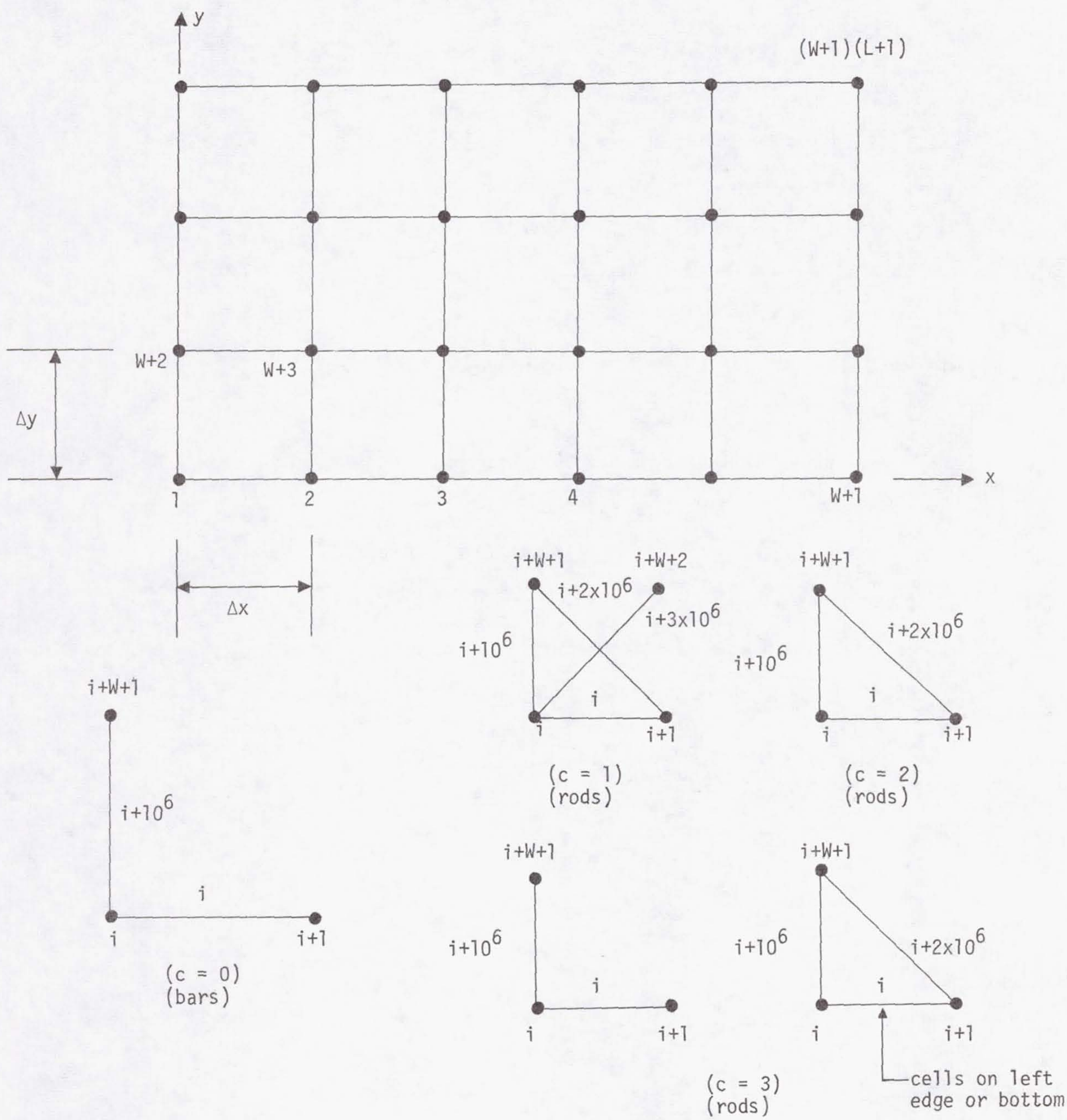
```
ID INPUTTST OPT1 LAPLACE STATICS
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,,G4,/C,N,1/C,N,1 $
EQUIV G2,GEØM2/TRUE  /  G4,GEØM4/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=LAPLACE CIRCUIT
LABEL=STATICS
SPC=1005
ØUTPUT
DISP=ALL
BEGIN BULK

ENDDATA
     5      1.0     10.0
```



Lines indicate scalar springs

2. Rectangular Frame mode from Bars or Rods (a = 2, c specifies bar-rod configuration)

INPUT generates GRID, CBAR, and SEQGP cards for the rectangular frame shown.



a. Data Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	P	(I8)	Permanent single-point constraints

b. Options (SEQGP cards)

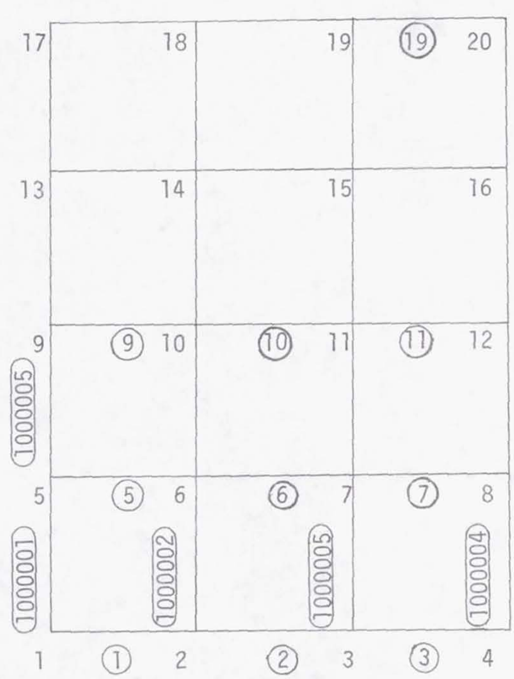
(1)	(b = 1)	Regular Banding (no SEQGP cards)
	(b = 2)	Double Banding
	(b = 3)	Active Columns
	(b = 4)	Reverse Double Banding
(2)	(c = 0)	Bars
	(c = 1)	Rods with both diagonals
	(c = 2)	Rods with UL - LR diagonals
	(c = 3)	Rods - statically determinate

c. Notes

(1) A PBAR card with PID of 101 must be supplied as part of the bulk data for $c = 0$; for $c \neq 0$, this is a PRØD card.

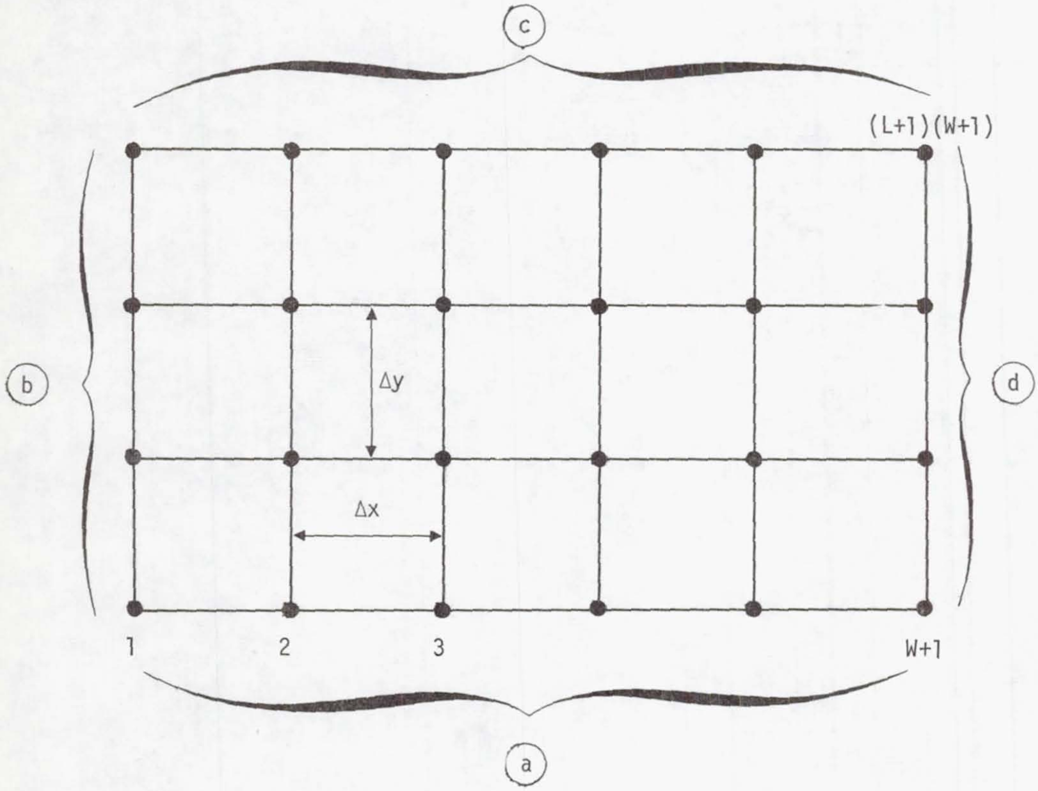
USER GENERATED INPUT

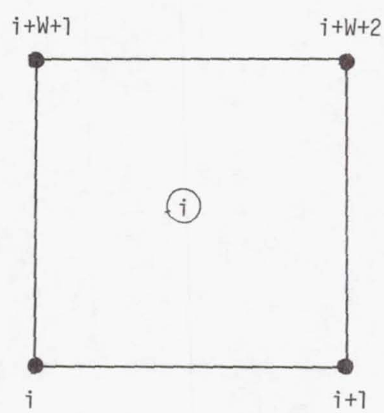
```
ID INPUTTST OPT2 FRAME
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,2/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR FRAME FROM BARS
LABEL=REGULAR BANDING
SPC=1
LØAD=1
ØUTPUT
SET 101 = 1,4,17,20
DISP=101
BEGIN BULK
FØRCE          1       20        0      1.0     1.0     0.0     0.0
MAT1           7      1.0      1.0
PBAR         101        7      1.0      2.0     4.0     8.0
SPC            1        1     1234      0.0       4      23     0.0
ENDDATA
       3       4      1.0      2.0      345
```



3. <u>Rectangular Plate made from QUAD1's (a = 3)</u>

INPUT generates GRID, CQUAD1, SEQGP, and SPC (if requested) cards for the rectangular grid work shown.





USER GENERATED INPUT

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	1P	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IYO	(I8)	SPC's on y = 0
2	IXO	(I8)	SPC's on x = 0
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$
5	IØX	(I8)	Omit's in x-direction
6	IØY	(I8)	Omit's in y-direction

b. Options

(1) SEQGP Options

a.	(b = 1)	Regular banding (no SEQGP cards)
b.	(b = 2)	Double banding
c.	(b = 3)	Active banding
c.	(b = 4)	Reverse double banding

c. Notes

(1) If IP, IYO, IXO, IYL, and IXW are all zero, G4 will be purged.

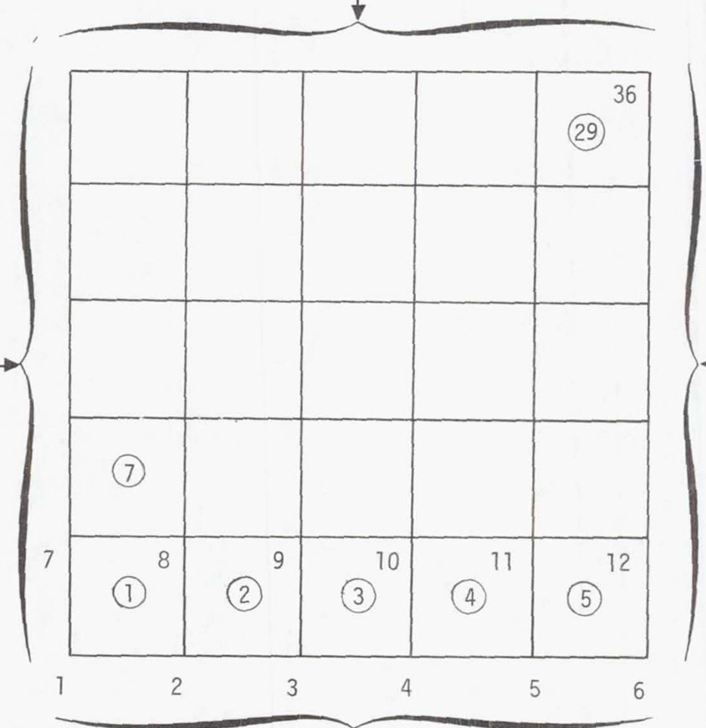
(2) A PQUAD1 card with PID = 101 must be included in the Bulk Data.

(3) If SPC's are generated the set id will be 1000NX + NY.

NASTRAN DATA DECK

```
ID INPUTTST ØPT3  $ PLATE FRØM QUAD1'S
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,G4,/C,N,3/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  /  G4,GEØM4/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FRØM CQUAD1'S
LABEL=STATICS               SIMPLE SUPPØRTS        REGULAR BAND
SPC=5005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FØRCE   1       1       0       1.0     0.0     0.0     1.0
MAT1    7       1.0     1.0
PQUAD1  101     7       1.0     7       2.0     7       4.0
ENDDATA
    5       5    10.0    10.0     126     0.0
  246     156   12356   12346     0       0
```

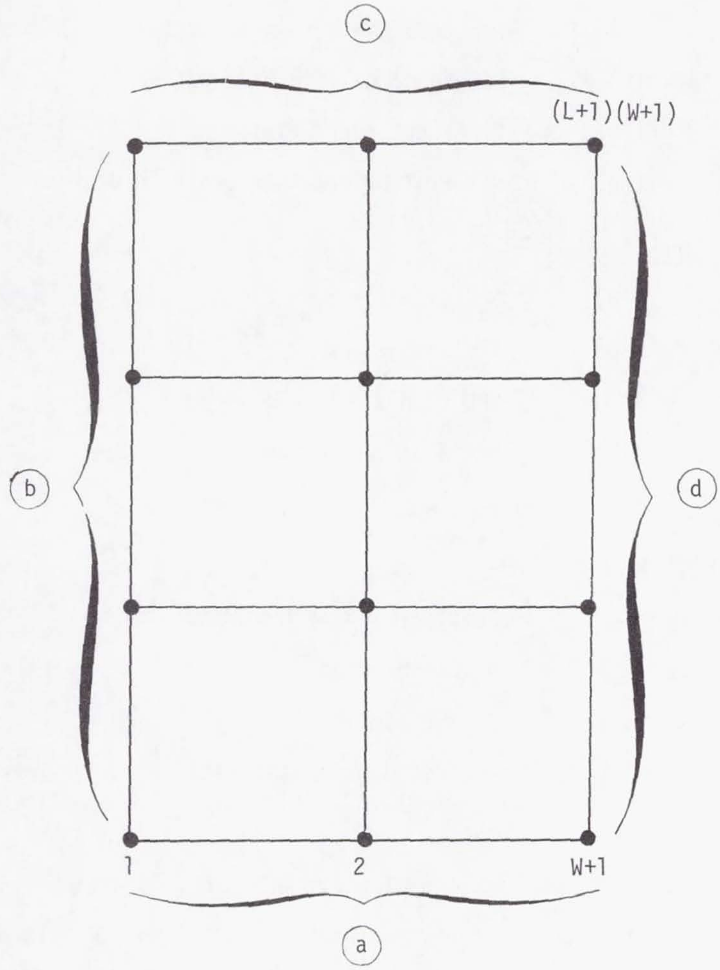
NØ ØMIT'S

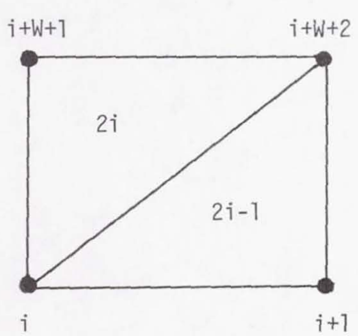


SPC SET ID IS GIVEN BY 1000 · W + L

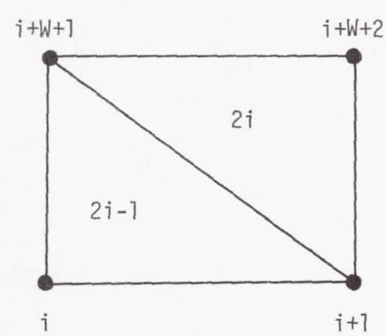
4. Rectangular Plate made from TRIA1's (a = 4)

INPUT generates GRID, CTRIA1, and SPC (if requested) cards for the rectangular grid work shown.





(c = 1)



(c = 2)

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degress

Second Card

1	IYO	(I8)	SPC's on $y = 0$
2	IXO	(I8)	SPC's on $x = 0$
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$

b. Options

(1) SEQGP Options

a. (b = 1)	Regular banding (no SEQGP cards)
b. (b = 2)	Double banding
c. (b = 3)	Active banding
d. (b = 4)	Reverse double banding

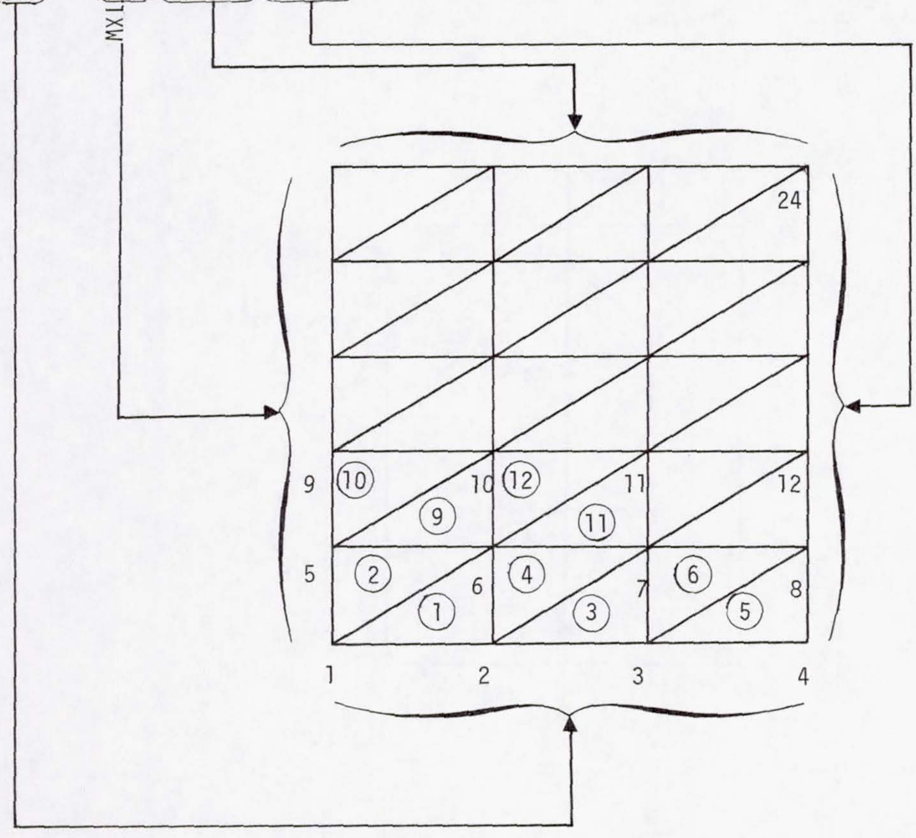
c. Notes

(1) If IP, IYO, IXO, IYL, and 1XW are all zero, G4 will be purged.

(2) A PTR1A1 card with PID=101 must be included in the Bulk Data.

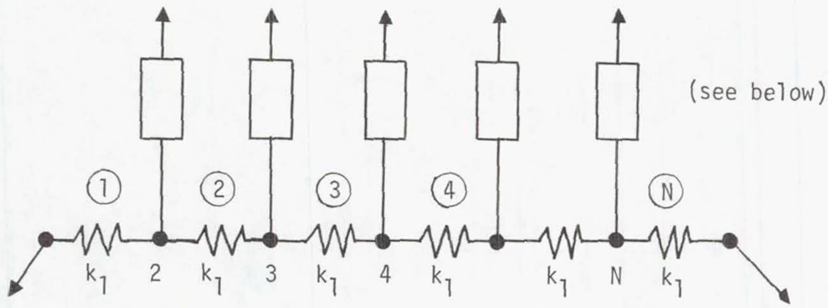
(3) If SPC's are generated the set id will be 1000NX + NY.

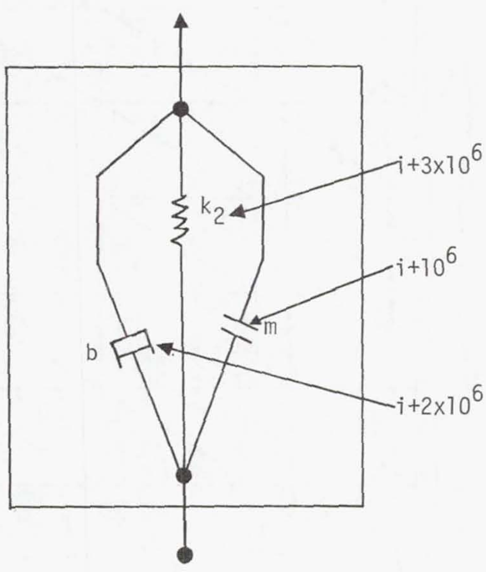
```
ID INPUTTST ØPT4 $  PLATE FRØM TRIA1'S
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,G4,/C,N,4/C,N,1/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  /  G4,GEØM4/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FROM CTRIA1'S
LABEL=ØPTION 1                  WITH CLAMPED SUPPØRTS
SPC=3005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FØRCE   1       1       0       1.0     0.0     0.0     1.0
MAT1    7       1.0     1.0
PTRIA1  101     7       1.0     7       2.0     7       4.0
ENDDATA
     3       5      2.0     1.0     126     0.0
   246     156   412356  512346
```



5. N-segment string (a = 5, b and c are not used)

INPUT generates CELAS4, CMASS4, and CDAMP4 cards for an N-segment string grounded at both ends.





USER GENERATED INPUT

a. Data Card

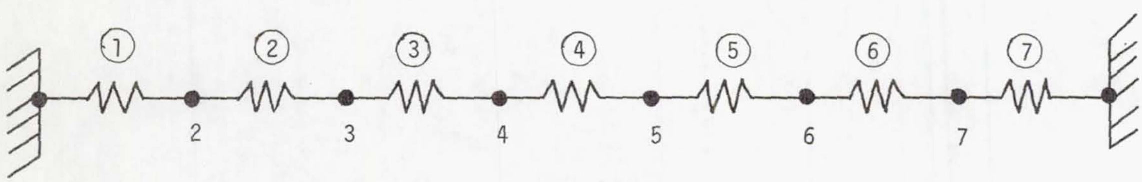
1	N	(I8)	No. of segments
2	k_1	(E8.0)	Spring value
3	k_2	(E8.0)	Spring value (if zero, none of these elements are generated)
4	m	(E8.0)	Mass value (if zero, none of these elements are generated)
5	b	(E8.0)	Damper values (if zero, none of these elements are generated)

b. Notes

(1) If any of k_2, m, or b are zero, those elements will not be generated.

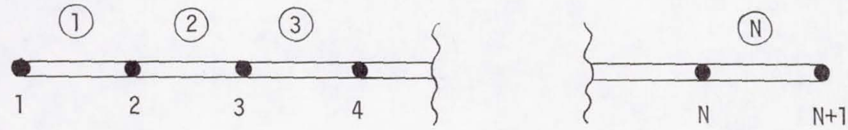
NASTRAN DATA DECK

```
ID INPUTTST ØPT5 STRING
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,,,/C,N,5 $
EQUIV G2,GEØM2/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=N-SEGMENT STRING
LABEL=STATICS
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
LØAD        1       3     1.0      6     1.0
ENDDATA
       7     1.0     0.0     0.0     0.0
```



6. N-cell Bar (a = 6, b and c are not used)

INPUT generates GRID and CBAR cards for an N-cell bar. ØMIT cards will also be created if requested.



a. Data Card(s)

1	N	(I8)	No. of cells
2	L	(E8.0)	Length of bar
3	IP	(I8)	Permanent constraints
4	IFLG	(I8)	Orientation vector flag
5	IGO	(I8)	GO (used only if IFLG = 2)
6	M	(I8)	No. of right-most grid points to be connected to GP2 via bars with PID = 102
7	IØX	(I8)	ØMIT CØUNT

Second Data Card (Read only if IFLG = 1)

1	X1	(E8.0)	Orientation vector X1 component
2	X2	(E8.0)	Orientation vector X2 component
3	X3	(E8.0)	Orientation vector X3 component

b. Notes

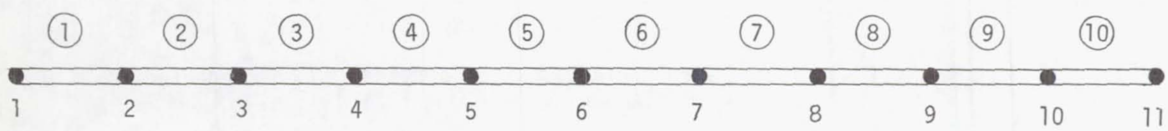
(1) A PBAR card with PID = 101 is required. If M ≠ 0, a PBAR card with PID = 102 is required.

(2) IFLG = 2 option does not work!

(3) Do not include G4 in alter packet unless IØX is greater than 0.

NASTRAN DATA DECK

```
ID INPUTTST ØPT6 BAR
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,6 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=N-CELL BAR
LABEL=STATICS
SPC=1
LØAD=1
ØUTPUT
SET 101=11
DISP=101
BEGIN BULK
FØRCE          1      11       0     1.0     0.0     1.0     1.0
MAT1           7     1.0     1.0
PBAR         101       7     1.0     2.0     4.0     8.0
SPC            1       1  123456     0.0
ENDDATA
PARAM   GRDPNT  6
      10   100.0       0       1       0       0       0
     0.0     0.0     1.0
```



7. Full matrix with optional unit load (a = 7, b and c are not used)

INPUT generates N scalar points, all of which are interconnected giving N(N+1)/2 elements. On option, SLØAD cards are generated for each CELAS4 scalar point.

a. Data Card

1	N	(I8)	Order of problem
2	NSLØAD	(I8)	Uniform load Generation Flag o => do not generate SLØAD cards ≠ 0 => generate SLØAD cards

b. Notes

(a) GP1 is altered as shown in the example in order to run efficiently.

(b) If SLØAD cards are generated the load set id is N.

NASTRAN DATA DECK

```
ID INPUTTST ØPT7 $ FILL MATRIX WITH ØPTIØNAL UNIT LØAD
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,G3,,G5/C,N,7 $
EQUIV G2,GEØM2/TRUE  /  G3,GEØM3/TRUE  $
ALTER 4,4
GP1 GEØM1,G5/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/C,N,0/V,N,NØGPDT $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=FULL MATRIX WITH ØPTIØNAL UNIT LØAD
LABEL=ØRDER = 10
LØAD=10
ØUTPUT
DISP=ALL
SPCF=ALL
ØLØAD=ALL
ELFØ=ALL
BEGIN BULK

ENDDATA
      10        1
```

3.1 GENERAL DESCRIPTION OF RIGID FORMATS

The most general way of using NASTRAN is with a user written Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The user may even choose to write a module of his own. The rules governing all of these operations are described in Section 5.

In order to relieve the user from the necessity of constructing a DMAP sequence for each of his problems, a number of such sequences have been included in NASTRAN as rigid formats. A rigid format consists of two parts. The first part is a DMAP sequence that is stored in NASTRAN and available to the user by specifying the number of the rigid format on the SØL card in the Executive Control Deck. The second part of a rigid format is a set of restart tables that automatically modify the series of DMAP operations to account for any changes that are made in any part of the Data Deck when making a restart, after having previously run all, or a part of the problem. Without such tables, the user would have to carefully modify his DMAP sequence to account for the conditions surrounding each restart. The chances for error in making these modifications for restart are very great. The restart tables not only relieve the user of the burden of modifying his DMAP sequence, but also assures him of a correct and efficient program execution.

In addition to the DMAP sequence provided with each rigid format, a number of options are available, which are subsets of each complete DMAP sequence. Subsets are selected by specifying the subset number (zero for the complete DMAP sequence) along with the rigid format number on the SØL card in the Executive Control Deck. Besides zero, the following subsets have been provided:

1. Remove all DMAP instructions associated with loop control (all rigid formats except 3 and 5)
2. Remove all DMAP instructions associated with the mode acceleration method of data recovery (rigid formats 11 and 12).
3. A union of subsets 1 and 2.

The removal of instructions associated with loop control assures the Executive System that each module will only be executed once, and that there is no possibility of branching back to a previously executed module. This permits the Executive System to drop files earlier in the execution that would otherwise have to be kept available for possible looping. The appearance of the REPT instruction in the DMAP sequence indicates the possibility of looping. The removal of the DMAP instructions associated with the mode acceleration method of data recovery allows more efficient

restarts. The deletion of operations for each subset is controlled by the restart tables.

If the user wishes to modify the DMAP sequence of a rigid format in some manner not provided for in the available subsets, he can use the ALTER feature described in Section 2. Typical uses are to schedule an EXIT prior to completion, in order to check intermediate output, schedule the printing of a table or matrix for diagnostic purposes, and to delete, or add a functional module to the DMAP sequence. Any DMAP instructions that are added to a rigid format are automatically executed when a restart is performed. The user should be familiar with the rules for DMAP programming, as described in Section 5, prior to making alterations to a rigid format.

The following rigid formats for structural analysis are currently included in NASTRAN:

1. Static Analysis
2. Static Analysis with Inertia Relief
3. Normal Mode Analysis
4. Static Analysis with Differential Stiffness
5. Buckling Analysis
6. Piecewise Linear Analysis
7. Direct Complex Eigenvalue Analysis
8. Direct Frequency and Random Reponse
9. Direct Transient Response
10. Modal Complex Eigenvalue Analysis
11. Modal Frequency and Random Response
12. Modal Transient Response

The following rigid formats for heat transfer analysis are included in NASTRAN:

1. Linear Static Analysis (This rigid format is identical to the structural analysis rigid format for static analysis, and is documented in Section 3.2.)
2. Nonlinear Static Analysis
3. Transient Analysis

3.1.1 Input File Processor

The Input File Processor operates in the Preface prior to the execution of the DMAP operations in the rigid format. A complete description of the operations in the Preface is given in the Programmer's Manual. The main interest here is to indicate the source of data blocks that

are created in the Preface and hence appear only as inputs in the DMAP sequences of the rigid formats. None of the data blocks created by the Input File Processor are checkpointed, as they are always regenerated on restart. The Input File Processor is divided into four parts. The first part (IFP1) processes the Case Control Deck, the second part (IFP) processes the Bulk Data Deck, the third part (IFP3) performs additional processing of the bulk data cards associated with the conical shell element, and the fourth part (IFP4) performs additional processing of the bulk data cards associated with the fluid element. The fifth section IFP5 processes data related to acoustic cavity analysis.

IFP1 processes the Case Control Deck and creates the Case Control Data Block (CASECC), the Plot Control Data Block (PCDB), and the XY-Plot Control Data Block (XYCDB). IFP1 also examines all of the cards, except those associated with plotting, for errors in format or use. If errors are detected, they are classed as either fatal or warning, and suitable error messages are provided. Reference to Section 2.3 will assist the user in correcting errors in the Case Control Deck. If the error is fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface.

The Bulk Data Deck is sorted in the Preface, if necessary, before the execution of the second part of the Input File Processor. IFP checks all of the bulk data cards for errors according to the rules given for each card in Section 2.4. If errors are detected, suitable messages are provided to the user. If the error is classed as fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface. IFP creates the data blocks that are input to the various parts of the Geometry Processor (GEØM1, GEØM2, GEØM3 and GEØM4), the Element Properties Table (EPT), the Material Properties Table (MPT), the Element Deformation Table (EDT), and the Direct Input Table (DIT).

The third part of the Input File Processor (IFP3) converts the information on the special conical shell cards (CCØNEAX, FØRCEAX, MØMAX, MPCAX, ØMITAX, PCØNEAX, PØINTAX, PRESAX, RINGAX, SECTAX, SPCAX, SUPAX, and TEMPAX) to reflect the number of harmonics specified by the user on the AXIC card. This converted information is added to any existing information on data blocks GEØM1, GEØM2, GEØM3 and GEØM4.

The fourth part of the input file processor (IFP4) converts the information on the fluid related cards (AXIF, BDYLIST, CFLUID2, CFLUID3, CFLUID4, DMIAX, FLSYM, FREEPT, FSLIST, GRIDB, PRESPT, and RINGFL) to reflect the desired harmonics, boundaries, and matrix input. This converted information is added to GEØM1, GEØM2, GEØM4, and MATPØØL.

The fifth part of the input file processor (IFP5) converts the information on the acoustic cavity related cards (AXSLØT, CAXIF2, CAXIF3, CAXIF4, CSLØT3, CSLØT4, GRIDF, GRIDS, and SLBDY) to equivalent structural scalar points, elements, scalar springs and plotting elements. This converted information is added to the GEØM1 and GEØM2 data blocks.

3.1.2 Functional Modules and Supporting DMAP Operations

The DMAP listings for the rigid formats currently included in NASTRAN are presented in the following sections. The mnemonics for the major functional modules are circled on the DMAP listings for ease of identification. Each major functional module is usually preceded and/or succeeded by several supporting DMAP operations. Brief descriptions of the operations in the func-

tional modules are given for each of the rigid formats. The complete details for each functional module are given in the Programmer's Manual. Additional information is also given in the Theoretical Manual. The format of a functional module DMAP instruction is given in Section 5.

Many of the executive modules in the following list appear repeatedly in the rigid formats. Since the purpose of many of these operations in a rigid format is obvious, they are frequently omitted from the descriptions of the DMAP operations in the following sections. More complete descriptions of the executive modules are given in Section 5.

1. BEGIN indicates the beginning of the DMAP sequence constituting the rigid format.

2. FILE makes declarations relative to a particular file.

   ABC = TAPE states that file ABC will be assigned to a physical tape if one is available.

   DEF = APPEND states that file DEF may be extended as the result of an internal loop in the rigid format.

   GHI = SAVE states that file GHI should not be dropped after use as it may be needed for subsequent executions of an internal loop.

3. CHKPNT specifies a list of files to be written on the new problem tape, including files that may have been purged, either because they were not generated in this particular execution or were explicitly purged with a PURGE statement.

4. LABEL specifies a labeled point in the sequence of DMAP instructions. Labels are referenced by REPT, JUMP and CØND instructions.

5. REPT specifies the end of a loop. The variable field contains the label name for the beginning of the loop and the number of times the loop is to be repeated.

6. JUMP specifies an unconditional transfer to the label indicated.

7. CØND specifies a conditional tranfer to the label indicated based on the value of the parameter named. The transfer occurs if the parameter value is negative.

8. SAVE specifies variable parameter values that are to be saved for future use.

9. PURGE specifies the names of files that are conditionally dropped based on the parameter named.

10. EQUIV specifies the names of files that are conditionally equivalenced based on the parameter named.

11. END indicates the end of the DMAP sequence constituting the rigid format and causes a normal termination when executed.

3.1.3 Restart Procedures

Scheduled exits can be requested at any point in a rigid format by means of the ALTER feature. An exit is scheduled by inserting the following cards in the Executive Control Deck:

```
ALTER    K1
EXIT     K2
```

ENDALTER

K1 = DMAP statement number after which exit will take place.

K2 = Number of times EXIT instruction will be skipped before being executed - default is zero. For use with loops, where user wishes to execute the loop K2 times before scheduling the exit.

If the user chooses to restart the problem without making any changes, the Executive System will execute an unmodified restart following the last completed checkpoint.

Unscheduled exits are usually caused by errors on input cards or errors in the structural model resulting from missing or inconsistent input data. When such errors are detected, an unscheduled exit is performed accompanied with the output of the applicable user error messages. Following the correction of the input data errors, a modified restart can be performed.

Unscheduled exits may also occur because of machine failure or insufficient time allowance. In these cases, an unmodified restart is usually made following the last completed checkpoint. In some cases, where a portion of the problem has been completed, including the output for the completed portion, a modified restart must be made following an unscheduled exit due to insufficient time allowance. These situations are discussed under case control requirements in the sections dealing with the individual rigid formats.

The initial execution of any problem must be made with a complete NASTRAN Data Deck, including all of the bulk data. However, all or part of the bulk data may be assembled from alternate input sources, such as the User's Master File or a module written by the user to generate input. The User's Master File is described in Section 2.5 and user generated input is discussed in Section 2.6.

A New Problem Tape is constructed only when checkpointing (CHKPNT) is requested in the Executive Control Deck. The New Problem Tape should be assigned to a physical tape or other storage device that can be dismounted and saved at the conclusion of the execution. At the completion of an initial execution, the New Problem Tape contains the input deck, with the bulk data in sorted form, and all of the files that were checkpointed during the execution.

For restarts, the Old Problem Tape is defined as the Problem Tape that was written during the previous execution. The New Problem Tape is defined as the Problem Tape written during the current execution, beginning with the restart. At the completion of an unmodified restart the New Problem Tape contains the input deck, with the bulk data in sorted form, all files from the Old Problem Tape that are necessary to complete the solution, and all of the files checkpointed

during the current execution. At the completion of a modified restart, the New Problem Tape is similar, except the input deck is modified according to the information submitted for the restart.

For restarts, the Bulk Data Deck consists only of delete cards (see Section 2.4) and new cards which the user wishes to add. The previous Bulk Data Deck is read from the Old Problem Tape. All other parts of the NASTRAN Data Deck, including the Executive Control Deck, the Case Control Deck, the BEGIN BULK card and the ENDDATA card must be resubmitted even though no changes are made in the control decks and no new bulk data is added. In addition, the RESTART cards punched during the previous execution must be included in the Executive Control Deck. When changing rigid formats, the solution number (SØL) must be changed to the number of the new rigid format.

Any changes in the Case Control Deck associated with bulk data selection or subcase definition, or changes in the Bulk Data Deck, in the form of deletions or additions, mark the restart as being modified. If no such changes are made, the Executive System performs an unmodified restart at the last completed checkpoint. If only changes have been made in the output requests, the restart is considered unmodified. However, some modules preceeding the last completed checkpoint may have to be executed in order to prepare the output.

For modified restarts, a number of previously executed DMAP instructions may have to be re-executed, depending on the nature of the modifications made by the user. The DMAP instructions that need to be executed in a modified restart are automatically determined within the program by comparing all changes made in Case Control cards and Bulk Data cards with the restart tables that are part of each rigid format. In addition, if the previous execution terminated prior to completion on the same rigid format, all DMAP instructions beyond the last completed checkpoint are executed on restart.

Each rigid format includes a two-dimensional restart table. The length of the table is equal to the number of DMAP instructions in the rigid format and the width of the table is arbitrarily set at 155 bit positions. Each restart table is subdivided into the following three parts:

1. Card Name Restart Table - Bit Positions 1-62.
2. Rigid Format Change Restart Table - Bit Positions 63-93
3. File Name Restart Table - Bit Positions 94-154.

See, for example, the restart tables associated with Static Analysis in Sections 3.2.3.3, 3.2.3.4 and 3.2.3.5 respectively. Bit positions 63-74 are associated with rigid formats 1-12

respectively. Bit positions 75-93 are reserved for additional rigid formats. Section 3.2.3.1 indicates the bit positions in the range 1-62 that are currently used in the Card Name Restart Table for Static Analysis. Section 3.2.3.2 indicates the bit positions in the range 94-154 that are currently used in the File Name Restart Table for Static Analysis. Similar tables exist for the other rigid formats.

Under restart conditions, any deletions or additions to the Bulk Data Deck cause the appropriate bit positions in the range 1-62 of a bit mask to be turned on. For example, if a new FØRCE card were introduced into the Bulk Data Deck on restart of a problem in Static Analysis, bit position 60 would be turned on. Mnemonics in the Card Name Restart Table with $ appended are associated with changes of conditions in the Case Control Deck. For example, SPC$ indicates a change in single-point constraint selection and would turn on bit position 10. PLØT$ indicates the presence of a request for structure plots and would turn on bit position 18.

If the restart is performed on a different rigid format than the previous exection, the bit position associated with the rigid format number for the previous execution is turned on in the bit mask. For example, if the previous execution were Normal Modes Analysis (rigid format number 3), bit number 65 in the mask would be turned on.

Following the preparation of this mask, it is compared with the first two parts of the restart table. Where bit positions that have been turned on in the mask match bit positions in the restart table (indicated by the presence of the units digit for the bit position), the associated DMAP instruction is marked for execution. For example, the addition of a new FØRCE card in Static Analysis (bit position 60) will mark the first three DMAP instructions for execution, GP3 along with the four following instructions, and several instructions near the end of the DMAP sequence, beginning with SSG1. If only the load set number had been changed in the Case Control Deck (LØAD$, bit position 59), GP3 and the four following instructions would not have been marked for execution.

Examination of the Rigid Format Change Restart Tables for Static Analysis indicates that changing from Normal Modes Analysis to Static Analysis (bit position 65) only marks the first three instructions and several instructions associated with data recovery for execution. Actually several other modules need to be executed as a result of the rigid format change. These additional modules will be identified with the aid of the File Name Restart Table.

If the previous operation marks modules for execution requiring files that will not be

generated and are not available on the Old Problem Tape, the bit positions for all such files are determined, and reference is made to the File Name Restart Table for a match to determine which DMAP instructions are required to generate the missing files. For example, in a Static Analysis restart, assume that the Static Load Table (SLT) is needed for restart and is not available. Section 3.2.3.2 indicates that the bit position for this file is 96, and Section 3.2.3.5 indicates that GP3 and the four following DMAP instructions should be executed to generate file SLT. This operation may mark modules for execution that result in further reference to the File Name Restart Table for needed files.

The restart table also contains the information indicating which DMAP instructions should be deleted for particular subsets of the rigid format. This information is arbitrarily placed in the Card Name Restart Table. The deletion of a DMAP instruction is indicated by following it with the symbols $SS with the affected subset numbers on the same line. For example, near the end of the Card Name Table for Static Analysis (Section 3.2.3.3), it is indicated that the DMAP instructions CØND, REPT, JUMP and LABEL are deleted for subsets 1 and 3.

3.1.4 Rigid Format Output

Although most of the rigid format output is optional, some of the printer output is automatic. The printer output is designed for 132 characters per line, with the lines per page controlled by the LINE card in the Case Control Deck. The default is LINE = 50 for 11-inch paper. Optional titles are printed at the top of each page from information in the Case Control Deck. These titles may be defined at the subcase level. The pages are automatically dated and numbered.

The output from data recovery and plot modules is all optional, and its selection is controlled by cards in the Case Control Deck. The details of making selections in the Case Control Deck are described in Section 2.3 for printer and punch output, and in Section 4 for plotter output. Since the outputs from the data recovery and plot modules vary considerably with the rigid format, a list of available output is included in the section on the Case Control Deck for each rigid format. Detail information on the force and stress output available for each element type is given in Section 1.3.

The first part of the output for a NASTRAN run is prepared during the execution of the Preface, prior to the beginning of the DMAP sequence of the rigid format. The following output is either automatically or optionally provided during the execution of the Preface:

1. NASTRAN title page - automatic
2. Executive Control Deck echo - automatic
3. Case Control Deck echo - automatic
4. Unsorted Bulk Data Deck echo - optional, selected in Case Control Deck.
5. Sorted Bulk Data Deck echo - automatic, unless suppressed in the Case Control Deck.
6. DMAP listing - automatic for restarts, otherwise selected with DIAG 14 in Executive Control Deck, list of DMAP instructions, including alters, for subset of rigid format being executed.
7. Checkpoint Dictionary - automatic, when operating in checkpoint mode. A printed echo and the punched cards are prepared for additions to the checkpoint dictionary after the execution of each checkpoint.

When making restarts, the following additional output is automatically prepared during the execution of the Preface:

1. Asterisks are placed beside the DMAP statement numbers of all instructions marked for execution by the Card Name Table in the case of modified restarts, and by the Rigid Format Change Table in the case of restarts on different rigid formats.
2. Message indicating the bit position activated by a rigid format change.
3. Table indicating, among other things, the card names and the associated "packed bit positions" activated by modifications in the NASTRAN Data Deck. The reader is referred to the Programmer's Manual for the interpretation of the rest of this table.
4. A list of files, along with the DMAP instructions that were marked for execution by the File Name Table.
5. List of files from the Old Problem Tape, including purged files, used to initiate the restart.

A number of fatal errors are detected by DMAP statements in the various rigid formats. The messages associated with these errors are documented in Section 6.1. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or they can be more effectively detected by DMAP statements in the rigid format.

NASTRAN diagnostic messages are usually identified by number and documented in Section 6.2. These messages may be either program diagnostics or user diagnostics, and they may contain information, warnings, or an indication of a fatal error. There are also a few unnumbered, self-explanatory messages, for example, the time that the execution of each functional module begins and ends.

The Grid Point Singularity Table (GPST) is automatically output following the execution of the Grid Point Singularity Processor (GPSP) if singularities remain in the stiffness matrix at the grid point level. This table contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. Entries in this

table should only be treated as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints. Further information on this matter is given in the Theoretical Manual.

Several items of output are discussed in other sections. Automatic output that is not associated with all of the rigid formats is discussed in the sections treating the individual rigid formats. Some output is under the control of PARAM cards. These items are discussed in Section 3.1.5. The DIAG card is used to control the printing of some output. A list of the available output under DIAG control is given in the description of the executive control cards in Section 2.2.1.

Any of the matrices or tables that are prepared by the functional modules can be printed by using selected utility modules described in Section 5.3.2. These utility modules can be scheduled at any point in the rigid format by using the ALTER feature. In general, they should be scheduled immediately after the functional module that generates the table or matrix to be printed. However, the user is cautioned to check the calling sequence for the utility module, in order to be certain that all required inputs have been generated prior to this point.

3.1.5 Use of Parameters

Some of the data items and user options are input on PARAM cards. Details on these cards are given in Sections 2.4 and 5.2.1.5. The following is a list of parameter names (field 2 of the PARAM card) that are available to the user:

1. GRDPNT - optional in all rigid formats. A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed. The value of the integer indicates the grid point to be used as a reference point. If the integer is zero or is not a defined grid point, the reference point is taken as the origin of the basic coordinate system. All fluid related masses are ignored. The following weight and balance information is automatically printed following the execution of the Grid Point Weight Generator.

   (1) Reference point.

   (2) Rigid body mass matrix [MO] relative to the reference point in the basic coordinate system.

   (3) Transformation matrix [S] from basic coordinate system to principal mass axes.

   (4) Principal masses and associated centers of gravity.

   (5) Inertia matrix I(S) about the center of gravity relative to the principal mass axes.

   (6) Inertia matrix I(Q) about the center of gravity relative to the principal inertia axes.

2. WTMASS - optional in all rigid formats. The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. IRES - optional in all statics problems (rigid formats 1, 2, 4, 5 and 6). A positive integer value of this parameter will cause the printing of the residual vectors following each execution of SSG3.

4. LFREQ and LFREQ - required in all modal formulations of dynamics problems (rigid formats 10, 11 and 12) unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required in all modal formulations of dynamics problems (rigid formats 10, 11 and 12) unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. G - optional in the direct formulation of all dynamics problems (rigid formats 7, 8 and 9). The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

7. W3 and W4 - optional in the direct formulation of transient response problems. The real values (radians/unit time) of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. The parameter W3 should not be used for hydroelastic problems.

8. MØDACC - optional in the modal formulation of frequency response and transient response problems. A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

9. CØUPMASS - optional in all rigid formats. A positive integer value of this parameter will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness. This option applies to both structural and nonstructural mass for the following elements: BAR, CØNRØD, QUAD1, QUAD2, RØD, TRIA1, TRIA2, TUBE. Since structural mass is not defined for the following list of elements, the option applies only to the nonstructural mass: QDPLT, TRBSC, TRPLT. A negative value causes the generation of lumped mass matrices (translational components only) for all the above elements. (This is the default). A zero value activates the following parameters described under 10.

10. CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC -- optional in all rigid formats. These parameters are active only if CØUPMASS=0. A positive value will cause the generation of coupled mass matrices for all elements of that particular type as shown by the following table:

Parameter	Element Types
CPBAR	BAR
CPRØD	RØD, CØNRØD
CPQUAD1	QUAD1
CPQUAD2	QUAD2
CPTRIA1	TRIA1
CPTRIA2	TRIA2
CPTUBE	TUBE
CPQDPLT	QDPLT
CPTRPLT	TRPLT
CPTRBSC	TRBSC

A negative value (the default) for these parameters will cause the generation of the lumped mass matrices (translational components only) for these element types.

11. DECØMØPT - optional for frequency response problems. The integer value of this parameter is used to control the type of arithmetic used in the decomposition of the dynamic equations. A value of 1 (default) means that double precision, complex arithmetic with partial pivoting will be used. A value of 2 means that double precision, complex arithmetic without pivoting will be used. A value of 4 means that single precision, complex arithmetic without pivoting will be used.

12. MAXIT - optional in nonlinear static heat transfer analysis. The integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.

13. EPSHT - optional in nonlinear static heat transfer analysis. The real value of this parameter is used to test the convergence of the nonlinear heat transfer solution (see Section 8.4.1 of the Theoretical Manual). The default value is .001.

14. TABS - optional in nonlinear static and transient heat transfer analysis. The real value of this parameter is the absolute reference temperature. The default value is 0.0.

15. SIGMA - optional in nonlinear static and transient heat transfer analysis. The real value of this parameter is the Stefan-Boltzmann constant. The default value is 0.0.

16. BETA - optional in transient heat transfer analysis. The real value of this parameter is used as a factor in the integration algorithm (see Section 8.4.2 of the Theoretical Manual). The default value is 0.55.

17. RADLIN - optional in transient heat transfer analysis. A positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.

3.2 STATIC ANALYSIS

3.2.1 DMAP Sequence for Static Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.1 STATIC ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  FILE      QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE $

  4  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/   C,N,
               123/V,N,NOGPDT $

  5  SAVE      LUSET $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  7  GP2       GEOM2,EQEXIN/ECT $

  8  CHKPNT    ECT $

  9  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/    V,N,
               JUMPPLOT $

 10  SAVE      NSIL,JUMPPLOT $

 11  PRTMSG    PLTSETX// $

 12  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 13  SAVE      PLTFLG,PFILE $

 14  COND      P1,JUMPPLOT $

 15  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 16  SAVE      JUMPPLOT,PLTFLG,PFILE $

 17  PRTMSG    PLOTX1// $

 18  LABEL     P1 $

 19  CHKPNT    PLTPAR,GPSETS,ELSETS $

 20  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 21  SAVE      NOGRAV $

 22  PARAM     //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

 23  PURGE     MGG/SKPMGG $

 24  CHKPNT    SLT,GPTT,MGG $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 25  TA1,       ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
                123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 26  SAVE       NOSIMP,NOGENL,GENEL $

 27  PARAM      //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

 28  COND       ERROR4,NOELMT $

 29  PURGE      GPST/NOSIMP/OGPST/GENEL $

 30  CHKPNT     EST,ECPT,GPCT,GEI,GPST,OGPST $

 31  COND       LBL1,NOSIMP $

 32  SMA1       CSTM,MPT,ECPT,GPCT, DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG/  V,Y,
                OPTION $

 33  CHKPNT     GPST,KGGX $

 34  COND       LBL1,SKPMGG $

 35  SMA2       CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
                V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
                Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
                CPTRBSC $

 36  SAVE       NOMGG $

 37  CHKPNT     MGG $

 38  COND       LBL1,GRDPNT $

 39  COND       ERROR2,NOMGG $

 40  GPWG       BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 41  OFP        OGPWG,,,,,//V,N,CARDNO $

 42  SAVE       CARDNO $

 43  LABEL      LBL1 $

 44  EQUIV      KGGX,KGG/NOGENL $

 45  CHKPNT     KGG $

 46  COND       LBL11A,NOGENL $

 47  SMA3       GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 48  CHKPNT     KGG $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 49  LABEL    LBL11A $

 50  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 51  JUMP     LBL11 $
                                                        Top of DMAP Loop
 52  LABEL    LBL11 $

 53  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,YS,USET,/V,N,LUSET/V,N,MPCF1/
              V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
              V,N,NOSET/V,N,NOL/V,N,NOA $

 54  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 55  COND     ERROR3,NOL $

 56  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 57  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,UOO,PO,UOOV,RUOV/OMIT/
              PS,KFS,KSS/SINGLE/QG/NOSR $

 58  EQUIV    KGG,KNN/MPCF1 $

 59  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,UOO,PO,UOOV,QG,PS,KFS,KSS,USET,RG,
              YS,RUOV,KNN $

 60  COND     LBL4,GENEL $

 61  GPSP     GPL,GPST,USET,SIL/OGPST $

 62  OFP      OGPST,,,,,//V,N,CARDNO $

 63  SAVE     CARDNO $

 64  LABEL    LBL4 $

 65  COND     LBL2,MPCF2 $

 66  MCE1     USET,RG/GM $

 67  CHKPNT   GM $

 68  MCE2     USET,GM,KGG,,,/KNN,,, $

 69  CHKPNT   KNN $

 70  LABEL    LBL2 $

 71  EQUIV    KNN,KFF/SINGLE $

 72  CHKPNT   KFF $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  COND      LBL3,SINGLE $
 74  SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $
 75  CHKPNT    KFS,KSS,KFF $
 76  LABEL     LBL3 $
 77  EQUIV     KFF,KAA/OMIT $
 78  CHKPNT    KAA $
 79  COND      LBL5,OMIT $
 80  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $
 81  CHKPNT    GO,KAA,KOO,LOO,UOO $
 82  LABEL     LBL5 $
 83  EQUIV     KAA,KLL/REACT $
 84  CHKPNT    KLL $
 85  COND      LBL6,REACT $
 86  RBMG1     USET,KAA,/KLL,KLR,KRR,,, $
 87  CHKPNT    KLL,KLR,KRR $
 88  LABEL     LBL6 $
 89  RBMG2     KLL/LLL,ULL $
 90  CHKPNT    ULL,LLL $
 91  COND      LBL7,REACT $
 92  RBMG3     LLL,ULL,KLR,KRR/DM $
 93  CHKPNT    DM $
 94  LABEL     LBL7 $
 95  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
               LUSET/V,N,NSKIP/V,Y,OPTION $
 96  CHKPNT    PG $
 97  EQUIV     PG,PL/NOSET $
 98  CHKPNT    PL $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 99  COND      LBL10,NCSET $

100  SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

101  CHKPNT    QR,PO,PS,PL $

102  LABEL     LBL10 $

103  SSG3      LLL,ULL,KLL,PL,LOO,UOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/ V,Y,
               IRES=-1/V,N,NSKIP/V,N,EPSI $

104  SAVE      EPSI $

105  CHKPNT    ULV,UOOV,RULV,RUOV $

106  COND      LBL9,IRES $

107  MATGPR    GPL,USET,SIL,RULV//C,N,L $

108  MATGPR    GPL,USET,SIL,RUOV//C,N,O $

109  LABEL     LBL9 $

110  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
               C,N,STATICS $

111  CHKPNT    UGV,PGG $

112  COND      LBL8,REPEAT $

113  REPT      LBL11,1CC $
_____________________________________________  Bottom of DMAP Loop
114  JUMP      ERROR1 $

115  PARAM     //C,N,NOT/V,N,TEST/V,N,REPEAT $

116  COND      ERROR5,TEST $

117  LABEL     LBL8 $

118  CHKPNT    QG $

119  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,PGG,QG,UGV,EST,/
               OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $

120  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO/V,Y,OPTION $

121  SAVE      CARDNO $

122  COND      P2,JUMPPLOT $

123  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1, /  PLOTX2/
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 1

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
              V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

124  SAVE     PFILE $

125  PRTMSG   PLOTX2// $

126  LABEL    P2 $

127  JUMP     FINIS $

128  LABEL    ERROR1 $

129  PRTPARM  //C,N,-1/C,N,STATICS $

130  LABEL    ERROR2 $

131  PRTPARM  //C,N,-2/C,N,STATICS $

132  LABEL    ERROR3 $

133  PRTPARM  //C,N,-3/C,N,STATICS $

134  LABEL    ERROR4 $

135  PRTPARM  //C,N,-4/C,N,STATICS $

136  LABEL    ERROR5 $

137  PRTPARM  //C,N,-5/C,N,STATICS $

138  LABEL    FINIS $

139  END      $
```

3.2.2 Description of DMAP Operations for Static Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

9. PLTSET transforms user input into a form used to drive structure plotter.

11. PRTMSG prints error messages associated with structure plotter.

14. Go to DMAP No. 18 if no undeformed structure plot request.

15. PLØT generates all requested undeformed structure plots.

17. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

20. GP3 generates Static Loads Table and Grid Point Temperature Table.

25. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 134 and print error message if no elements have been defined.

31. Go to DMAP No. 43 if there are no structural elements.

32. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

34. Go to DMAP No. 43 if no gravity loads and no weight and balance request.

35. SMA2 generates mass matrix $[M_{gg}]$.

38. Go to DMAP No. 43 if no weight and balance request.

39. Go to DMAP No. 130 and print error message if no mass matrix exists.

40. GPWG generates weight and balance information.

41. ØFP formats weight and balance information and places it on the system output file for printing.

44. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

46. Go to DMAP No. 49 if no general elements.

47. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

51. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

52. Beginning of Loop for additional constraint sets.

53. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

55. Go to DMAP No. 132 and print error message if no independent degrees of freedom are defined.

58. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

60. Go to DMAP No. 64 if general elements present.

61. GPSP determines if possible grid point singularities remain.

62. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

65. Go to DMAP No. 70 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

79. Go to DMAP No. 82 if no omitted coordinates.

80. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

83. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

85. Go to DMAP No. 88 if no free-body supports.

86. RBMG1 partitions out-free body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. Go to DMAP No. 94 if no free-body supports.

92. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] \quad ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] \quad ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} \quad .$$

95. SSG1 generates static load vectors $\{P_g\}$.

97. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

100. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ \hline P_m\end{array}\right\} \quad , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} \quad ,$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ \hline P_s\end{array}\right\} \quad , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} \quad ,$$

$$\{P_f\} = \left\{\begin{array}{c}\bar{P}_a \\ \hline P_o\end{array}\right\} \quad , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} \quad ,$$

$$\{P_a\} = \left\{\begin{array}{c}P_\ell \\ \hline P_r\end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

103. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates.

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}}$$

106. Go to DMAP No. 109 if residual vectors are not to be printed.

107. MATGPR prints the residual vector for independent coordinates (RULV)

108. MATGPR prints the residual vector for omitted coordinates (RUØV).

110. SDR1 recovers dependent displacements

$$\left\{\begin{matrix} u_\ell \\ \hline u_r \end{matrix}\right\} = \{u_a\} , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\left\{\begin{matrix} u_a \\ \hline u_o \end{matrix}\right\} = \{u_f\} , \qquad \left\{\begin{matrix} u_f \\ \hline Y_s \end{matrix}\right\} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{matrix} u_n \\ \hline u_m \end{matrix}\right\} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

112. Go to DMAP No. 117 if all constraint sets have been processed.

113. Go to DMAP No. 52 if additional sets of constraints need to be processed.

114. Go to DMAP No. 128 and print error message if number of loops exceeds 100.

116. Go to DMAP No. 136 and print error message if multiple boundary conditions are attempted with improper subset.

119. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

120. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

122. Go to DMAP No. 126 if no deformed structure plots are requested.

123. PLØT generates all requested deformed structure plots.

125. PRTMSG prints plotter data and engineering data for each deformed plot generated.

127. Go to DMAP No. 138 and make normal exit.

129. STATIC ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

131. STATIC ANALYSIS ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

133. STATIC ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

135. STATIC ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

137. STATIC ANALYSIS ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.2.3 Restart Tables for Static Analysis

3.2.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CROD	2	MATT5	8
ADUM2	1	CSHEAR	2	TABLEM1	8
ADUM3	1	CTETRA	2	TABLEM2	8
ADUM4	1	CTORDRG	2	TABLEM3	8
ADUM5	1	CTRAPRG	2	TABLEM4	8
ADUM6	1	CTRBSC	2	TEMPMT$	8
ADUM7	1	CTRIA1	2	TEMPMX$	8
ADUM8	1	CTRIA2	2	AXISYM$	9
ADUM9	1	CTRIARG	2	MPC	9
AXIC	1	CTRMEM	2	MPCADD	9
AXIF	1	CTRPLT	2	MPCAX	9
CELAS1	1	CTUBE	2	MPC$	9
CELAS2	1	CTWIST	2	SPC	10
CELAS3	1	CWEDGE	2	SPC1	10
CELAS4	1	PBAR	3	SPCADD	10
CMASS1	1	PCONEAX	3	SPCAX	10
CMASS2	1	PDUM1	3	SPC$	10
CMASS3	1	PDUM2	3	ASET	11
CMASS4	1	PDUM3	3	ASET1	11
CORD1C	1	PDUM4	3	OMIT	11
CORD1R	1	PDUM5	3	OMIT1	11
CORD1S	1	PDUM6	3	OMITAX	11
CORD2C	1	PDUM7	3	SUPAX	12
CORD2R	1	PDUM8	3	SUPORT	12
CORD2S	1	PDUM9	3	TEMP	13
GRDSET	1	PHBDY	3	TEMPAX	13
GRID	1	PQDMEM	3	TEMPD	13
GRIDB	1	PQDMEM1	3	TEMPP1	13
POINTAX	1	PQDMEM2	3	TEMPP2	13
RINGAX	1	PQDMEM3	3	TEMPP3	13
RINGFL	1	PQDPLT	3	TEMPRB	13
SECTAX	1	PQUAD1	3	WTMASS	14
SEQGP	1	PQUAD2	3	GRDPNT	15
SPOINT	1	PROD	3	PLOTEL	16
BAROR	2	PSHEAR	3	IRES	17
CBAR	2	PTORDRG	3	PLOT$	18
CCONEAX	2	PTRBSC	3	POUT$	19
CDUM1	2	PTRIA1	3	LOOP$	22
CDUM2	2	PTRIA2	3	LOOP1$	23
CDUM3	2	PTRMEM	3	COUPMASS	24
CDUM4	2	PTRPLT	3	CPBAR	24
CDUM5	2	PTUBE	3	CPQDPLT	24
CDUM6	2	PTWIST	3	CPQUAD1	24
CDUM7	2	GENEL	4	CPQUAD2	24
CDUM8	2	CONM1	5	CPROD	24
CDUM9	2	CONM2	5	CPTRBSC	24
CHBDY	2	PELAS	6	CPTRIA1	24
CHEXA1	2	PMASS	7	CPTRIA2	24
CHEXA2	2	MAT1	8	CPTRPLT	24
CONROD	2	MAT2	8	CPTUBE	24
CQDMEM	2	MAT3	8	SPCD	56
CQDMEM1	2	MAT4	8	DEFORM	59
CQDMEM2	2	MAT5	8	DEFORM$	59
CQDMEM3	2	MATT1	8	LOAD$	59
CQDPLT	2	MATT2	8	RFORCE$	59
CQUAD1	2	MATT3	8	FORCE	60
CQUAD2	2	MATT4	8	FORCE1	60

Card Name	Bit Pos.
FORCE2	60
FORCEAX	60
LOAD	60
MOMAX	60
MOMENT	60
MOMENT1	60
MOMENT2	60
PLOAD	60
PLOAD1	60
PLOAD2	60
PRESAX	60
QBDY1	60
QBDY2	60
QHBDY	60
QVECT	60
QVOL	60
SLOAD	60
GRAV	61
RFORCE	61
TEMPLD$	62

3.2.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.	File Name	Bit Pos.
BGPDT	94	KLL	107
CSTM	94	KLR	107
EQEXIN	94	KRR	107
GPDT	94	LLL	108
GPL	94	ULL	108
SIL	94	DM	109
ECT	95	PG	110
GPTT	96	PL	111
SLT	96	PO	111
ECPT	97	PS	111
EST	97	QR	111
GEI	97	RULV	112
GPCT	97	RUOV	112
GPST	98	ULV	112
KGGX	98	UOOV	112
MGG	99	PGG	113
KGG	100	QG	113
RG	101	UGV	113
USET	101	OEF1	114
YS	101	OES1	114
OGPST	102	OPG1	114
GM	103	OQG1	114
KNN	104		
KFF	105		
KFS	105		
KSS	105		
GO	106		
KAA	106		
KOO	106		
LOO	106		
UOO	106		

3.2.3.3 Card Name Restart Table

Bit Position

DMAP Inst.	1 – 10	– 20	– 30	– 40	– 50	– 60	
BEGIN	1234567890	123456789	234			90	12
FILE	1234567890	123456789	234			90	12
FILE	1234567890	123456789	234			90	12
$SS	1 3						
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	12	3				0	1
SAVE	12	3				0	1
PARAM	12	3 5				0	1
PURGE	12	3 5				0	1
CHKPNT	12	3 5				0	1
TA1	1234567	3					
SAVE	1234567	3					
PARAM	1234567	3					
COND	1234567	3					
PURGE	1234567	3					
CHKPNT	1234567	3					
COND	123 5678	45	4				1
SMA1	123 6 8						
CHKPNT	123 6 8						
COND	123 5 78	45	4				1
SMA2	123 5 78	45	4				1
SAVE	123 5 78	45	4				1
CHKPNT	123 5 78	45	4				1
COND	123 5 78	45	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				1
LABEL	123 5 78	45	4				1
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	12	23				
JUMP			23				
$SS	1 3						
LABEL			23				
$SS	1 3						
GP4	1 90	12	23			6	
SAVE	1 90	12	23			6	

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
COND	1 90	12	23			6	
PARAM	1 90	12	23			6	
PURGE	1 90	12	23			6	
EQUIV	1234 6 89		23			6	
CHKPNT	1234 6 890	12	23			6	
COND	123 6 890		23				
GPSP	123 6 890		23				
OFP	123 6 890		23				
SAVE	123 6 890		23				
LABEL	123 6 890		23				
COND	1234 6 89		23				
MCE1	1 9		23				
CHKPNT	1 9		23				
MCE2	1234 6 89		23				
CHKPNT	1234 6 89		23				
LABEL	1234 6 89		23				
EQUIV	1234 6 890		23				
CHKPNT	1234 6 890		23				
COND	1234 6 890		23				
SCE1	1234 6 890		23				
CHKPNT	1234 6 890		23				
LABEL	1234 6 890		23				
EQUIV	1234 6 890	1	23				
CHKPNT	1234 6 890	1	23				
COND	1234 6 890	1	23				
SMP1	1234 6 890	1	23				
CHKPNT	1234 6 890	1	23				
LABEL	1234 6 890	1	23				
EQUIV	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
COND	1234 6 890	12	23				
RBMG1	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
LABEL	1234 6 890	12	23				
RBMG2	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
COND	1234 6 890	12	23				
RBMG3	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
LABEL	1234 6 890	12	23				
SSG1	123 5678		23			90	12
CHKPNT	123 5678		23			90	12
EQUIV	123 567890	12	23			6 90	12
CHKPNT	123 567890	12	23			6 90	12
COND	123 567890	12	23			6 90	12
SSG2	123 567890	12	23			6 90	12
CHKPNT	123 567890	12	23			6 90	12
LABEL	123 567890	12	23			6 90	12
SSG3	1234567890	12	23			6 90	12
SAVE	1234567890	12	23			6 90	12
CHKPNT	1234567890	12	23			6 90	12
COND	1234567890	12 7	23			6 90	12
MATGPR	1234567890	12 7	23			6 90	12
MATGPR	1234567890	12 7	23			6 90	12
LABEL	1234567890	12 7	23			6 90	12
SDR1	1234567890	12	23			6 90	12
CHKPNT	1234567890	12	23			6 90	12

```
DMAP                         Bit Position
Inst.      1       10        20        30        40        50        60
COND                            23
$SS        1 3
REPT                            23
$SS        1 3
JUMP                            23
$SS        1 3
PARAM                           23
COND                            23
LABEL                           23
$SS        1 3
CHKPNT     123456789012                                              9012
SDR2                        89
OFP                          9
SAVE                         9
COND                        8
PLOT                        8
SAVE                        8
PRTMSG                      8
LABEL                       8
JUMP       1234567890123456789  234                               6  9012
LABEL      1234567890123456789  234                               6  9012
$SS        1 3
PRTPARM    1234567890123456789  234                               6  9012
$SS        1 3
LABEL      1234567890123456789  234                               6  9012
PRTPARM    1234567890123456789  234                               6  9012
LABEL      1234567890123456789  234                               6  9012
PRTPARM    1234567890123456789  234                               6  9012
LABEL      1234567890123456789  234                               6  9012
PRTPARM    1234567890123456789  234                               6  9012
LABEL      1234567890123456789  234                               6  9012
PRTPARM    1234567890123456789  234                               6  9012
LABEL      1234567890123456789  234                               6  9012
END        1234567890123456789  234                               6  9012
```

3.2.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position (64 – 70 – 80)
BEGIN	45678901234
FILE	45678901234
FILE	45678901234
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
SAVE	
PARAM	
PURGE	
CHKPNT	
TA1,	
SAVE	
PARAM	45678901234
COND	45678901234
PURGE	
CHKPNT	
COND	
SMA1	
CHKPNT	
COND	
SMA2	
SAVE	
CHKPNT	
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
JUMP	
LABEL	
GP4	
SAVE	
COND	45678901234
PARAM	
PURGE	

DMAP Inst.	Bit Position (64 – 70 – 80)
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
RBMG1	
CHKPNT	
LABEL	
RBMG2	
CHKPNT	
COND	
RBMG3	
CHKPNT	
LABEL	
SSG1	
CHKPNT	
EQUIV	
CHKPNT	
COND	
SSG2	
CHKPNT	
LABEL	
SSG3	4
SAVE	4
CHKPNT	4
COND	45678901234
MATGPR	45678901234
MATGPR	45678901234
LABEL	45678901234
SDR1	45678901234
CHKPNT	45678901234
COND	45678901234
REPT	45678901234
JUMP	45678901234

DMAP Inst.	Bit Position 64 70 80
PARAM	45678901234
COND	45678901234
LABEL	45678901234
CHKPNT	45678901234
SDR2	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
JUMP	45678901234
LABEL	45678901234
PRTPARM	45678901234
LABEL	45678901234
PRTPARM	45678901234
LABEL	45678901234
PRTPARM	45678901234
LABEL	45678901234
PRTPARM	45678901234
LABEL	45678901234
PRTPARM	45678901234
LABEL	45678901234
END	45678901234

3.2.3.5 File Name Restart Table

DMAP Inst.	Bit Position 94	100	110	120	DMAP Inst.	Bit Position 94	100	110	120
BEGIN					EQUIV		4		
FILE					CHKPNT				
FILE					COND		2		
GP1	4				GPSP		2		
SAVE	4				OFP		2		
CHKPNT	4				SAVE		2		
GP2	5				LABEL		2		
CHKPNT	5				COND		34		
PLTSET			5		MCE1		3		
SAVE			5		CHKPNT		3		
PRTMSG			5		MCE2		4		
SETVAL			5		CHKPNT		4		
SAVE			5		LABEL		34		
COND					EQUIV		5		
PLOT					CHKPNT		5		
SAVE					COND		5		
PRTMSG					SCE1		5		
LABEL					CHKPNT		5		
CHKPNT			5		LABEL		5		
GP3	6				EQUIV		6		
SAVE	6				CHKPNT		6		
PARAM	6				COND		6		
PURGE	6 9				SMP1		6		
CHKPNT	6				CHKPNT		6		
TA1,	7				LABEL		6		
SAVE	7				EQUIV		7		
PARAM	7				CHKPNT		7		
COND	7				COND		7		
PURGE	78	2			RBMG1		7		
CHKPNT	7				CHKPNT		7		
COND	89				LABEL		7		
SMA1	8				RBMG2		8		
CHKPNT	8				CHKPNT		8		
COND	9				COND		9		
SMA2	9				RBMG3		9		
SAVE	9				CHKPNT		9		
CHKPNT	9				LABEL		9		
COND					SSG1			0	
COND					CHKPNT			0	
GPWG					EQUIV			1	
OFP					CHKPNT			1	
SAVE					COND			1	
LABEL	89				SSG2			1	
EQUIV		0			CHKPNT			1	
CHKPNT		0			LABEL			1	
COND		0			SSG3			2	
SMA3		0			SAVE			2	
CHKPNT		0			CHKPNT			2	
LABEL		0			COND				
PARAM		1			MATGPR				
JUMP		1			MATGPR				
LABEL		0			LABEL				
GP4		1			SDR1			3	
SAVE		1			CHKPNT			3	
COND		1			COND				
PARAM		1			REPT				
PURGE		1 3 567 9	1		JUMP				

DMAP Inst.	94	Bit Position 100	110	120
PARAM				
COND				
LABEL				
CHKPNT			3	
SDR2			4	
OFP				
SAVE				
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
JUMP				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.2.4 Case Control Deck and Parameters for Static Analysis

The following items relate to subcase definition and data selection for Static Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection unless all loading is specified with grid point displacements on SPC cards.

3. An SPC set must be selected for (not necessarily within) each subcase, unless the model is a properly supported free body, or all constraints are specified on GRID cards, Scalar Connection cards, or with General Elements.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following output may be requested for Static Analysis solutions:

1. Displacements and nonzero components of static loads and single-point forces of constraint at selected grid points or scalar points.

2. Forces and stresses in selected elements.

3. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.2.5 Case Control Deck and Parameters for Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Static Heat Transfer Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection, unless all loading is specified with grid point temperatures on SPC cards.
3. An SPC set must be selected for (not necessarily within) each subcase, unless all constraints are specified on GRID cards or Scalar Connection cards.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases, in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following output may be requested for Static Heat Transfer Analysis solutions:

1. Temperatures (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.
2. The punch option of a THERMAL request will produce TEMP bulk data cards.
3. Flux density (ELFØRCE) in selected elements.
4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Static Heat Transfer Analysis:

1. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

3.3 STATIC ANALYSIS WITH INERTIA RELIEF

3.3.1 DMAP Sequence for Static Analysis with Inertia Relief

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.2 STATIC ANALYSIS WITH INERTIA RELIEF - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  FILE      QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE/MNN=SAVE $

  4  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  5  SAVE      LUSET $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  7  GP2       GEOM2,EQEXIN/ECT $

  8  CHKPNT    ECT $

  9  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

 10  SAVE      NSIL,JUMPPLOT $

 11  PRTMSG    PLTSETX// $

 12  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 13  SAVE      PLTFLG,PFILE $

 14  COND      P1,JUMPPLOT $

 15  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 16  SAVE      JUMPPLOT,PLTFLG,PFILE $

 17  PRTMSG    PLOTX1// $

 18  LABEL     P1 $

 19  CHKPNT    PLTPAR,GPSETS,ELSETS $

 20  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 21  CHKPNT    SLT,GPTT $

 22  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 23  SAVE      NOSIMP,NOGENL,GENEL $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  COND       ERROR1,NOSIMP $

 25  PURGE      OGPST/GENEL $

 26  CHKPNT     EST,ECPT,GPCT,GEI,OGPST $

 27  SMA1       CSTM,MPT,ECPT,GPCT, DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 28  CHKPNT     GPST,KGGX $

 29  SMA2       CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
                V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
                Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
                CPTRBSC $

 30  SAVE       NOMGG $

 31  COND       ERROR1,NOMGG $

 32  CHKPNT     MGG $

 33  COND       LGPWG,GRDPNT $

 34  GPWG       BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 35  OFP        OGPWG,,,,,//V,N,CARDNO $

 36  SAVE       CARDNO $

 37  LABEL      LGPWG $

 38  EQUIV      KGGX,KGG/NOGENL $

 39  CHKPNT     KGG $

 40  COND       LBL11A,NOGENL $

 41  SMA3       GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 42  CHKPNT     KGG $

 43  LABEL      LBL11A $

 44  PARAM      //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 45  JUMP       LBL11 $
---------------------------------------------------------  Top of DMAP Loop
 46  LABEL      LBL11 $

 47  GP4        CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,YS,USET,/V,N,LUSET/V,N,MPCF1/
                V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
                V,N,NOSET/V,N,NOL/V,N,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 49  COND     ERROR3,NOL $

 50  COND     ERROR4,REACT $

 51  PURGE    GM/MPCF1/GO,KOO,LOO,UOO,MOO,MOA,PO,UOOV,RUOV/OMIT/KSS,KFS,PS/
              SINGLE $

 52  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 53  CHKPNT   GM,RG,GO,KOO,LOO,UOO,MOO,MOA,PO,KSS,KFS,YS,PS,USET,RUOV,KNN,
              MNN $

 54  COND     LBL4,GENEL $

 55  GPSP     GPL,GPST,USET,SIL/OGPST $

 56  OFP      OGPST,,,,,//V,N,CARDNO $

 57  SAVE     CARDNO $

 58  LABEL    LBL4 $

 59  COND     LBL2,MPCF2 $

 60  MCE1     USET,RG/GM $

 61  CHKPNT   GM $

 62  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

 63  CHKPNT   KNN,MNN $

 64  LABEL    LBL2 $

 65  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 66  CHKPNT   KFF,MFF $

 67  COND     LBL3,SINGLE $

 68  SCE1     USET,KNN,MNN,,/KFF,KFS,KSS,MFF,, $

 69  CHKPNT   KFS,KSS,KFF,MFF $

 70  LABEL    LBL3 $

 71  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $

 72  CHKPNT   KAA,MAA $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  COND      LBL5,OMIT $

 74  SMP1      USET,KFF,MFF,,/GO,KAA,KOO,LOO,UOO,MAA,MOO,MOA,, $

 75  CHKPNT    GO,KAA,KOO,LOO,UOO,MAA,MOO,MOA $

 76  LABEL     LBL5 $

 77  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 78  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 79  RBMG2     KLL/LLL,ULL $

 80  CHKPNT    ULL,LLL $

 81  RBMG3     LLL,ULL,KLR,KRR/DM $

 82  CHKPNT    DM $

 83  RBMG4     DM,MLL,MLR,MRR/MR $

 84  CHKPNT    MR $

 85  SSG1      SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
               LUSET/V,N,NSKIP $

 86  CHKPNT    PG $

 87  SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

 88  CHKPNT    QR,PO,PS,PL $

 89  SSG4      PL,QR,PO,MR,MLR,DM,MLL,MOO,MOA,GO,USET/PLI,POI/V,N,OMIT $

 90  CHKPNT    PLI,POI $

 91  SSG3      LLL,ULL,KLL,PLI,LOO,UOO,KOO,POI/ULV,UOOV,RULV,RUOV/V,N,OMIT/
               V,Y,IRES=-1/V,N,NSKIP/V,N,EPSI $

 92  SAVE      EPSI $

 93  CHKPNT    ULV,UOOV,RULV,RUOV $

 94  COND      LBL9,IRES $

 95  MATGPR    GPL,USET,SIL,RULV//C,N,L $

 96  MATGPR    GPL,USET,SIL,RUOV//C,N,O $

 97  LABEL     LBL9 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

  98  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
               C,N,STATICS $

  99  CHKPNT   UGV,QG,PGG $

 100  COND     LBL8,REPEAT $

 101  REPT     LBL11,100 $                                  Bottom of DMAP Loop
 ---------------------------------------------------------
 102  JUMP     ERROR2 $

 103  PARAM    //C,N,NOT/V,N,TEST/V,N,REPEAT $

 104  COND     ERROR5,TEST $

 105  LABEL    LBL8 $

 106  CHKPNT   CSTM $

 107  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,PGG,QG,UGV,EST,/
               OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $

 108  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

 109  SAVE     CARDNO $

 110  COND     P2,JUMPPLOT $

 111  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1, /  PLOTX2/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 112  SAVE     PFILE $

 113  PRTMSG   PLOTX2// $

 114  LABEL    P2 $

 115  JUMP     FINIS $

 116  LABEL    ERROR1 $

 117  PRTPARM  //C,N,-1/C,N,INERTIA $

 118  LABEL    ERROR2 $

 119  PRTPARM  //C,N,-2/C,N,INERTIA $

 120  LABEL    ERROR3 $

 121  PRTPARM  //C,N,-3/C,N,INERTIA $

 122  LABEL    ERROR4 $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 2

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

123  PRTPARM   //C,N,-4/C,N,INERTIA $

124  LABEL     ERROR5 $

125  PRTPARM   //C,N,-5/C,N,INERTIA $

126  LABEL     FINIS $

127  END       $
```

3.3.2 Description of DMAP Operations for Static Analysis with Inertia Relief

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

9. PLTSET transforms user input into a form used to drive structure plotter.

11. PRTMSG prints error messages associated with structure plotter.

14. Go to DMAP No. 18 if no undeformed structure plot request.

15. PLØT generates all requested undeformed structure plots.

17. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

20. GP3 generates Static Loads Table and Grid Point Temperature Table.

22. TA1 generates element tables for use in matrix assembly and stress recovery.

24. Go to DMAP No. 116 and print error message if there are no structural elements.

27. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

29. SMA2 generates mass matrix $[M_{gg}]$.

31. Go to DMAP No. 116 and print error message if no mass matrix exists.

33. Go to DMAP No. 37 if no weight and balance request.

34. GPWG generates weight and balance information.

35. ØFP formats weight and balance information and places it on the system output file for printing.

38. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

40. Go to DMAP No. 43 if no general elements.

41. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

45. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

46. Beginning of Loop for additional constraint sets.

47. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

49. Go to DMAP No. 120 and print error message if no independent degrees of freedom are defined.

50. Go to DMAP No. 122 and print error message if no free-body supports.

52. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

54. Go to DMAP No. 58 if general elements present.

55. GPSP determines if possible grid point singularities remain.

56. ØFP Formats table of possible grid point singularities and places it on the system output file for printing.

59. Go to DMAP No. 64 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

60. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

62. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

65. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

67. Go to DMAP No. 70 if no single-point constraints.

68. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

71. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

73. Go to DMAP No. 76 if no omitted coordinates.

74. SMP1 partitions constrained stiffness and mass matrices

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] \quad \text{and} \quad [M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reductions $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

and $[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$.

77. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right].$$

79. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

81. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

83. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

85. SSG1 generates static load vectors $\{P_g\}$.

87. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ \hline P_m\end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ \hline P_s\end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c}\bar{P}_a \\ \hline P_o\end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c}P_\ell \\ \hline P_r\end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

89. SSG4 calculates inertia loads and combines them with static loads

$$\{P_\ell^i\} = \{P_\ell\} + [M_{\ell\ell}][D] + [M_{\ell r}]\,[m_r]^{-1}\{q_r\} \qquad \text{and}$$

$$\{P_o^i\} = \{P_o\} + [M_{oo}][G_o] + [M_{ao}^T]\left\{\frac{D}{I}\right\}[m_r]^{-1}\{q_r\} \;.$$

91. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell^i\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o^i\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell^i\} = \{P_\ell^i\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell^i\}}{\{P_\ell^i\}^T\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o^i\} = \{P_o^i\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o^i\}}{\{P_o^i\}^T\{u_o^o\}}$$

94. Go to DMAP No. 97 if residual vectors are not to be printed.

95. Print residual vector for independent coordinates (RULV)

96. Print residual vector for omitted coordinates (RUØV).

98. SDR1 recovers dependent displacements

$$\left\{\begin{array}{c} u_\ell \\ \hline u_r \end{array}\right\} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\left\{\begin{array}{c} u_a \\ \hline u_o \end{array}\right\} = \{u_f\} , \qquad \left\{\begin{array}{c} u_f \\ \hline Y_s \end{array}\right\} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{array}{c} u_n \\ \hline u_m \end{array}\right\} = \{u_g\}$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

100. Go to DMAP No. 105 if all constraint sets have been processed.

101. Go to DMAP No. 46 if additional sets of constraints need to be processed.

102. Go to DMAP No. 118 and print error message if number of loops exceeds 100.

104. Go to DMAP No. 124 and print error message if multiple boundary conditions are attempted with improper subset.

107. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

108. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

110. Go to DMAP No. 114 if no deformed structure plots are requested.

111. PLØT generates all requested deformed structure plots.

113. PRTMSG prints plotter data and engineering data for each deformed plot generated.

115. Go to DMAP No. 126 and make normal exit.

117. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

119. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

121. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

123. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 4 - FREE-BØDY SUPPØRTS ARE REQUIRED.

125. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN A NØN-LØØPING SUBSET.

3.3.3 Restart Tables for Static Analysis with Inertia Relief

3.3.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CSHEAR	2	TEMPMX$	8
ADUM2	1	CTETRA	2	AXISYM$	9
ADUM3	1	CTORDRG	2	MPC	9
ADUM4	1	CTRAPRG	2	MPCADD	9
ADUM5	1	CTRBSC	2	MPCAX	9
ADUM6	1	CTRIA1	2	MPC$	9
ADUM7	1	CTRIA2	2	SPC	10
ADUM8	1	CTRIARG	2	SPC1	10
ADUM9	1	CTRMEM	2	SPCADD	10
AXIC	1	CTRPLT	2	SPCAX	10
AXIF	1	CTUBE	2	SPC$	10
CELAS1	1	CTWIST	2	ASET	11
CELAS2	1	CWEDGE	2	ASET1	11
CELAS3	1	PBAR	3	OMIT	11
CELAS4	1	PCONEAX	3	OMIT1	11
CMASS1	1	PDUM1	3	OMITAX	11
CMASS2	1	PDUM2	3	SUPAX	12
CMASS3	1	PDUM3	3	SUPORT	12
CMASS4	1	PDUM4	3	TEMP	13
CORD1C	1	PDUM5	3	TEMPAX	13
CORD1R	1	PDUM6	3	TEMPD	13
CORD1S	1	PDUM7	3	TEMPP1	13
CORD2C	1	PDUM8	3	TEMPP2	13
CORD2R	1	PDUM9	3	TEMPP3	13
CORD2S	1	PQDMEM	3	TEMPRB	13
GRDSET	1	PQDMEM1	3	WTMASS	14
GRID	1	PQDMEM2	3	GRDPNT	15
GRIDB	1	PQDMEM3	3	PLOTEL	16
POINTAX	1	PQDPLT	3	IRES	17
RINGAX	1	PQUAD1	3	PLOT$	18
RINGFL	1	PQUAD2	3	POUT$	19
SECTAX	1	PROD	3	LOOP$	22
SEQGP	1	PSHEAR	3	LOOP1$	23
SPOINT	1	PTORDRG	3	COUPMASS	24
BAROR	2	PTRBSC	3	CPBAR	24
CBAR	2	PTRIA1	3	CPQDPLT	24
CCONEAX	2	PTRIA2	3	CPQUAD1	24
CDUM1	2	PTRMEM	3	CPQUAD2	24
CDUM2	2	PTRPLT	3	CPROD	24
CDUM3	2	PTUBE	3	CPTRBSC	24
CDUM4	2	PTWIST	3	CPTRIA1	24
CDUM5	2	GENEL	4	CPTRIA2	24
CDUM6	2	CONM1	5	CPTRPLT	24
CDUM7	2	CONM2	5	CPTUBE	24
CDUM8	2	PELAS	6	SPCD	56
CDUM9	2	PMASS	7	DEFORM	59
CHEXA1	2	MAT1	8	DEFORM$	59
CHEXA2	2	MAT2	8	LOAD$	59
CONROD	2	MAT3	8	RFORCE$	59
CQDMEM	2	MATT1	8	FORCE	60
CQDMEM1	2	MATT2	8	FORCE1	60
CQDMEM2	2	MATT3	8	FORCE2	60
CQDMEM3	2	TABLEM1	8	FORCEAX	60
CQDPLT	2	TABLEM2	8	LOAD	60
CQUAD1	2	TABLEM3	8	MOMAX	60
CQUAD2	2	TABLEM4	8	MOMENT	60
CROD	2	TEMPMT$	8	MOMENT1	60

Card Name	Bit Pos.
MOMENT2	60
PLOAD	60
PLOAD1	60
PLOAD2	60
PRESAX	60
SLOAD	60
GRAV	61
RFORCE	61
TEMPLD$	62

3.3.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
SLT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
KNN	104
MNN	104
KFF	105
KFS	105
KSS	105
MFF	105
GO	106
KAA	106
KOO	106
LOO	106
MAA	106
MOA	106
MOO	106
UOO	106
KLL	107
KLR	107
KRR	107
MLL	107
MLR	107
MRR	107
LLL	108
ULL	108
DM	109
MR	110
PG	111
PL	112
PO	112
PS	112
QR	112
PLI	113
POI	113
RULV	114
RUOV	114
ULV	114
UOOV	114
PGG	115
QG	115
UGV	115
OEF1	116
OES1	116
OPG1	116
OQG1	116
OUGV1	116
PUGV1	116
ELSETS	117
GPSETS	117
PLTPAR	117
PLTSETX	117

3.3.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456789	234			90	12
FILE	1234567890	123456789	234			90	12
FILE	1234567890	123456789	234			90	12
$SS	1 3						
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	12	3				0	1
CHKPNT	12	3				0	1
TA1	1234567	3					
SAVE	1234567	3					
COND	12345678	34	4				
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4				
SAVE	123 5 78	4	4				
COND	123 5 78	4	4				
CHKPNT	123 5 78	4	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45	4				
EQUIV	123 6 8						
CHKPNT	123 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	12	23				
JUMP			23				
$SS	1 3						
LABEL			23				
$SS	1 3						
GP4	1 90	12	23			6	
SAVE	1 90	12	23			6	
COND	1 90	12	23			6	
COND	1 90	12	23			6	
PURGE	1 90	12	23			6	
EQUIV	123456789		23			6	
CHKPNT	1234567890	12	23			6	
COND	123 6 890		23				

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
GPSP	123 6 890		23				
OFP	123 6 890		23				
SAVE	123 6 890		23				
LABEL	123 6 890		23				
COND	123456789		23				
MCE1	1 9		23				
CHKPNT	1 9		23				
MCE2	123456789		23				
CHKPNT	123456789		23				
LABEL	123456789		23				
EQUIV	1234567890		23				
CHKPNT	1234567890		23				
COND	1234567890		23				
SCE1	1234567890		23				
CHKPNT	1234567890		23				
LABEL	1234567890		23				
EQUIV	1234567890	1	23				
CHKPNT	1234567890	1	23				
COND	1234567890	1	23				
SMP1	1234567890	1	23				
CHKPNT	1234567890	1	23				
LABEL	1234567890	1	23				
RBMG1	1234567890	12	23				
CHKPNT	1234567890	12	23				
RBMG2	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
RBMG3	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
RBMG4	1234567890	12	23				
CHKPNT	1234567890	12	23				
SSG1	123 5678		23			90	12
CHKPNT	123 5678		23			90	12
SSG2	123 567890	12	23			6 90	12
CHKPNT	123 567890	12	23			6 90	12
SSG4	123 567890	12	23			6 90	12
CHKPNT	123 567890	12	23			6 90	12
SSG3	1234567890	12	23			6 90	12
SAVE	1234567890	12	23			6 90	12
CHKPNT	1234567890	12	23			6 90	12
COND	1234567890	12 7	23			6 90	12
MATGPR	1234567890	12 7	23			6 90	12
MATGPR	1234567890	12 7	23			6 90	12
LABEL	1234567890	12 7	23			6 90	12
SDR1	1234567890	12	23			6 90	12
CHKPNT	1234567890	12	23			6 90	12
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
PARAM			23				
COND			23				
LABEL			23				
$SS	1 3						
CHKPNT		9					
SDR2		89					

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
JUMP	1234567890	123456789	234			6 90	12
LABEL	1234567890	123456789	234			6 90	12
PRTPARM	1234567890	123456789	234			6 90	12
LABEL	1234567890	123456789	234			6 90	12
$SS	1 3						
PRTPARM	1234567890	123456789	234			6 90	12
$SS	1 3						
LABEL	1234567890	123456789	234			6 90	12
PRTPARM	1234567890	123456789	234			6 90	12
LABEL	1234567890	123456789	234			6 90	12
PRTPARM	1234567890	123456789	234			6 90	12
LABEL	1234567890	123456789	234			6 90	12
PRTPARM	1234567890	123456789	234			6 90	12
LABEL	1234567890	123456789	234			6 90	12
END	1234567890	123456789	234			6 90	12

3.3.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 ... 70 ... 80
BEGIN	3 5678901234
FILE	3 5678901234
FILE	3 5678901234
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
COND	
PURGE	
CHKPNT	
SMA1	
CHKPNT	
SMA2	3 678
SAVE	3 678
COND	3 5678901234
CHKPNT	3 678
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
JUMP	
LABEL	
GP4	
SAVE	
COND	3 5678901234
COND	3 5678901234
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	

DMAP Inst.	Bit Position 63 ... 70 ... 80
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
LABEL	
RBMG1	
CHKPNT	
RBMG2	
CHKPNT	
RBMG3	
CHKPNT	
RBMG4	
CHKPNT	
SSG1	
CHKPNT	
SSG2	
CHKPNT	
SSG4	
CHKPNT	
SSG3	3
SAVE	3
CHKPNT	3
COND	3 5678901234
MATGPR	3 5678901234
MATGPR	3 5678901234
LABEL	3 5678901234
SDR1	3 5678901234
CHKPNT	3 5678901234
COND	3 5678901234
REPT	3 5678901234
JUMP	3 5678901234
PARAM	3 5678901234
COND	3 5678901234
LABEL	3 5678901234
CHKPNT	
SDR2	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	

DMAP Inst.	Bit Position 63 70 80
JUMP	3 5678901234
LABEL	3 5678901234
PRTPARM	3 5678901234
LABEL	3 5678901234
PRTPARM	3 5678901234
LABEL	3 5678901234
PRTPARM	3 5678901234
LABEL	3 5678901234
PRTPARM	3 5678901234
LABEL	3 5678901234
PRTPARM	3 5678901234
LABEL	3 5678901234
END	3 5678901234

3.3.3.5 File Name Restart Table

DMAP Inst.	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
BEGIN																											
FILE																											
FILE																											
GP1	4																										
SAVE	4																										
CHKPNT	4																										
GP2		5																									
CHKPNT		5																									
PLTSET																								7			
SAVE																								7			
PRTMSG																								7			
SETVAL																								7			
SAVE																								7			
COND																											
PLOT																											
SAVE																											
PRTMSG																											
LABEL																											
CHKPNT																								7			
GP3			6																								
CHKPNT			6																								
TA1,				7																							
SAVE				7																							
COND				7		9																					
PURGE				7					2																		
CHKPNT				7																							
SMA1					8																						
CHKPNT					8																						
SMA2						9																					
SAVE						9																					
COND						9																					
CHKPNT						9																					
COND																											
GPWG																											
OFP																											
SAVE																											
LABEL																											
EQUIV							0																				
CHKPNT							0																				
COND							0																				
SMA3							0																				
CHKPNT							0																				
LABEL							0																				
PARAM								1																			
JUMP																											
LABEL							0																				
GP4								1																			
SAVE								1																			
COND								1																			
COND								1																			
PURGE								1		3		5	6						2		4						
EQUIV											4																
CHKPNT																											
COND									2																		
GPSP									2																		
OFP									2																		
SAVE									2																		

DMAP Inst.	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
LABEL									2																		
COND										3	4																
MCE1										3																	
CHKPNT										3																	
MCE2											4																
CHKPNT											4																
LABEL										3	4																
EQUIV												5															
CHKPNT												5															
COND												5															
SCE1												5															
CHKPNT												5															
LABEL												5															
EQUIV													6														
CHKPNT													6														
COND													6														
SMP1													6														
CHKPNT													6														
LABEL													6														
RBMG1														7													
CHKPNT														7													
RBMG2															8												
CHKPNT															8												
RBMG3																9											
CHKPNT																9											
RBMG4																	0										
CHKPNT																	0										
SSG1																		1									
CHKPNT																		1									
SSG2																			2								
CHKPNT																			2								
SSG4																				3							
CHKPNT																				3							
SSG3																					4						
SAVE																					4						
CHKPNT																					4						
COND																											
MATGPR																											
MATGPR																											
LABEL																											
SDR1																						5					
CHKPNT																						5					
COND																											
REPT																											
JUMP																											
PARAM																											
COND																											
LABEL																											
CHKPNT																											
SDR2																							6				
OFP																											
SAVE																											
COND																											
PLOT																											
SAVE																											
PRTMSG																											
LABEL																											

DMAP Inst.	94	Bit Position 100	110	120
JUMP				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.3.4 Case Control Deck and Parameters for Static Analysis with Inertia Relief

The following items relate to subcase definition and data selection for Static Analysis with Inertia Relief:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection.

3. An SPC set may be selected only if used to remove grid point singularities or some, but not all, of the free body motions. At least one free body support must be provided with a SUPØRT card in the Bulk Data Deck.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets for the same output item.

The following output may be requested for Static Analysis with Inertia Relief:

1. Displacements at selected grid points due to the sum of the applied loads and the inertia loads.

2. Nonzero components of the applied static loads at selected grid points.

3. Reactions on free-body supports due to applied loads (single-point forces of constraint).

4. Forces and stresses in selected elements due to the sum of the applied loads and inertia loads.

5. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Inertia Relief:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.4 NORMAL MODE ANALYSIS

3.4.1 DMAP Sequence for Normal Mode Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

  1  BEGIN     NO.3 NORMAL MODES ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

  9  SAVE      NSIL,JUMPPLOT $

 10  PRTMSG    PLTSETX// $

 11  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 12  SAVE      PLTFLG,PFILE $

 13  COND      P1,JUMPPLOT $

 14  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 15  SAVE      JUMPPLOT,PLTFLG,PFILE $

 16  PRTMSG    PLOTX1//$

 17  LABEL     P1 $

 18  CHKPNT    PLTPAR,GPSETS,ELSETS $

 19  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 20  CHKPNT    GPTT $

 21  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 22  SAVE      NOGENL,NOSIMP,GENEL $

 23  COND      ERROR1,NOSIMP $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  PURGE     OGPST/GENEL $

 25  CHKPNT    EST,ECPT,GPCT,GEI,OGPST $

 26  SMA1      CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 27  CHKPNT    KGGX,GPST $

 28  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
               V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
               Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
               CPTRBSC $

 29  SAVE      NOMGG $

 30  COND      ERROR1,NOMGG $

 31  CHKPNT    MGG $

 32  COND      LGPWG,GRDPNT $

 33  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 34  OFP       OGPWG,,,,,//V,N,CARDNO $

 35  SAVE      CARDNO $

 36  LABEL     LGPWG $

 37  EQUIV     KGGX,KGG/NOGENL $

 38  CHKPNT    KGG $

 39  COND      LBL11,NOGENL $

 40  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 41  CHKPNT    KGG $

 42  LABEL     LBL11 $

 43  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 44  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1/ V,
               N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
               V,N,NOSET/V,N,NOL/V,N,NOA $

 45  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 46  COND      ERROR3,NOL $

 47  PURGE     KRR,KLR,DM,MLR,MR/REACT/GM/MPCF1/GO/OMIT/KFS/SINGLE/QG/NOSET $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 49  CHKPNT   KRR,KLR,DM,MLR,MR,GM,RG,GO,KFS,QG,USET,KNN,MNN $

 50  COND     LBL4,GENEL $

 51  GPSP     GPL,GPST,USET,SIL/OGPST $

 52  OFP      OGPST,,,,,//V,N,CARDNO $

 53  SAVE     CARDNO $

 54  LABEL    LBL4 $

 55  COND     LBL2,MPCF2 $

 56  MCE1     USET,RG/GM $

 57  CHKPNT   GM $

 58  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

 59  CHKPNT   KNN,MNN $

 60  LABEL    LBL2 $

 61  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 62  CHKPNT   KFF,MFF $

 63  COND     LBL3,SINGLE $

 64  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 65  CHKPNT   KFS,KFF,MFF $

 66  LABEL    LBL3 $

 67  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $

 68  CHKPNT   KAA,MAA $

 69  COND     LBL5,OMIT $

 70  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 71  CHKPNT   GO,KAA $

 72  SMP2     USET,GO,MFF/MAA $

 73  CHKPNT   MAA $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3

```
      N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 74  LABEL     LBL5 $

 75  COND      LBL6,REACT $

 76  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 77  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 78  RBMG2     KLL/LLL,ULL $

 79  CHKPNT    ULL,LLL $

 80  RBMG3     LLL,ULL,KLR,KRR/DM $

 81  CHKPNT    DM $

 82  RBMG4     DM,MLL,MLR,MRR/MR $

 83  CHKPNT    MR $

 84  LABEL     LBL6 $

 85  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
               LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/   V,
               N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 86  SAVE      NOEED $

 87  COND      ERROR2,NOEED $

 88  CHKPNT    EED $

 89  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
               NEIGV $

 90  SAVE      NEIGV $

 91  CHKPNT    LAMA,PHIA,MI,OEIGS $

 92  OFP       LAMA,OEIGS,,,,//V,N,CARDNO $

 93  SAVE      CARDNO $

 94  COND      FINIS,NEIGV $

 95  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $

 96  CHKPNT    PHIG,QG $

 97  PARAM     //C,N,SUB/V,N,SCALAR/V,N,SIL/V,N,LUSET $

 98  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 99  CHKPNT    SIP,BGPDP $

100  COND      LBL7,SCALAR $

101  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $

102  SAVE      LUSEP $

103  CHKPNT    BGPDP,SIP $

104  LABEL     LBL7 $

105  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,/,OQG1,
               OPHIG,OES1,OEF1,PPHIG/C,N,REIG $

106  OFP       OPHIG,OQG1,OEF1,OES1,,//V,N,CARDNO $

107  SAVE      CARDNO $

108  COND      P2,JUMPPLOT $

109  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG /  PLOTX2/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

110  SAVE      PFILE $

111  PRTMSG    PLOTX2// $

112  LABEL     P2 $

113  JUMP      FINIS $

114  LABEL     ERROR1 $

115  PRTPARM   //C,N,-1/C,N,MODES $

116  LABEL     ERROR2 $

117  PRTPARM   //C,N,-2/C,N,MODES $

118  LABEL     ERROR3 $

119  PRTPARM   //C,N,-3/C,N,MODES $

120  LABEL     FINIS $

121  END       $
```

3.4.2 Description of DMAP Operations for Normal Mode Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

8. PLTSET transforms user input into a form used to drive structure plotter.

10. PRTMSG prints error messages associated with structure plotter.

13. Go to DMAP No. 17 if no undeformed structure plot request.

14. PLØT generates all requested undeformed structure plots.

16. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

19. GP3 generates Grid Point Temperature Table.

21. TA1 generates element tables for use in matrix assembly and stress recovery.

23. Go to DMAP No. 114 and print error message if there are no structural elements.

26. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

28. SMA2 generates mass matrix $[M_{gg}]$.

30. Go to DMAP No. 114 and print error message if no mass matrix exists.

32. Go to DMAP No. 36 if no weight and balance request.

33. GPWG generates weight and balance information.

34. ØFP formats weight and balance information and places it on the system output file for printing.

37. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

39. Go to DMAP No. 42 if no general elements.

40. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

44. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

46. Go to DMAP No. 118 and print error message if no independent degrees of freedom are defined.

48. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

50. Go to DMAP No. 54 if general elements present.

51. GPSP determines if possible grid point singularities remain.

52. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

55. Go to DMAP No. 60 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 74 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

72. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

75. Go to DMAP No. 84 if no free-body supports.

76. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right].$$

78. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

80. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

82. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

85. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

87. Go to DMAP No. 116 and print error message if no Eigenvalue Extraction Data.

89. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D\ \phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

92. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

94. Go to DMAP No. 120 and exit if no eigenvalues found.

95. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \quad \begin{Bmatrix} \phi_a \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f\} \quad ,$$

$$\begin{Bmatrix} \phi_f \\ -- \\ \phi_s \end{Bmatrix} = \{\phi_n\} \quad , \quad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\begin{Bmatrix} \phi_n \\ -- \\ \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

98. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

101. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

105. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØQG1).

106. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

108. Go to DMAP No. 112 if no deformed structure plots are requested.

109. PLØT generates all requested deformed structure plots.

111. PRTMSG prints plotter data and engineering data for each deformed plot generated.

113. Go to DMAP No. 120 and make normal exit.

115. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

117. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

119. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.4.3 Restart Tables for Normal Mode Analysis

3.4.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CFLUID2	2	CONM2	5
ADUM2	1	CFLUID3	2	FSLIST	5
ADUM3	1	CFLUID4	2	PELAS	6
ADUM4	1	CONROD	2	PMASS	7
ADUM5	1	CQDMEM	2	MAT1	8
ADUM6	1	CQDMEM1	2	MAT2	8
ADUM7	1	CQDMEM2	2	MAT3	8
ADUM8	1	CQDMEM3	2	MATT1	8
ADUM9	1	CQDPLT	2	MATT2	8
AXIC	1	CQUAD1	2	MATT3	8
AXIF	1	CQUAD2	2	TABLEM1	8
AXSLOT	1	CROD	2	TABLEM2	8
CELAS1	1	CSHEAR	2	TABLEM3	8
CELAS2	1	CSLOT3	2	TABLEM4	8
CELAS3	1	CSLOT4	2	TEMPMT$	8
CELAS4	1	CTETRA	2	TEMPMX$	8
CMASS1	1	CTORDRG	2	MPC	9
CMASS2	1	CTRAPRG	2	AXISYM$	9
CMASS3	1	CTRBSC	2	MPCADD	9
CMASS4	1	CTRIA1	2	MPCAX	9
CORD1C	1	CTRIA2	2	MPC$	9
CORD1R	1	CTRIARG	2	SPC	10
CORD1S	1	CTRMEM	2	SPC1	10
CORD2C	1	CTRPLT	2	SPCADD	10
CORD2R	1	CTUBE	2	SPCAX	10
CORD2S	1	CTWIST	2	SPC$	10
FREEPT	1	CWEDGE	2	ASET	11
GRDSET	1	PBAR	3	ASET1	11
GRID	1	PCONEAX	3	OMIT	11
GRIDB	1	PDUM1	3	OMIT1	11
GRIDF	1	PDUM2	3	OMITAX	11
GRIDS	1	PDUM3	3	SUPAX	12
POINTAX	1	PDUM4	3	SUPORT	12
PRESPT	1	PDUM5	3	TEMP	13
RINGAX	1	PDUM6	3	TEMPAX	13
RINGFL	1	PDUM7	3	TEMPD	13
SECTAX	1	PDUM8	3	TEMPP1	13
SEQGP	1	PDUM9	3	TEMPP2	13
SLBDY	1	PQDMEM	3	TEMPP3	13
SPOINT	1	PQDMEM1	3	TEMPRB	13
BAROR	2	PQDMEM2	3	WTMASS	14
CAXIF2	2	PQDMEM3	3	GRDPNT	15
CAXIF3	2	PQDPLT	3	PLOTEL	16
CAXIF4	2	PQUAD1	3	PLOT$	18
CBAR	2	PQUAD2	3	POUT$	19
CCONEAX	2	PROD	3	COUPMASS	24
CDUM1	2	PSHEAR	3	CPBAR	24
CDUM2	2	PTORDRG	3	CPQDPLT	24
CDUM3	2	PTRBSC	3	CPQUAD1	24
CDUM4	2	PTRIA1	3	CPQUAD2	24
CDUM5	2	PTRIA2	3	CPROD	24
CDUM6	2	PTRMEM	3	CPTRBSC	24
CDUM7	2	PTRPLT	3	CPTRIA1	24
CDUM8	2	PTUBE	3	CPTRIA2	24
CDUM9	2	PTWIST	3	CPTRPLT	24
CHEXA1	2	GENEL	4	CPTUBE	24
CHEXA2	2	CONM1	5	EIGR	61

3.4.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGG	100
RG	101
USET	101
OGPST	102
GM	103
KNN	104
MNN	104
KFF	105
KFS	105
MFF	105
GO	106
KAA	106
KLL	107
KLR	107
KRR	107
MLL	107
MLR	107
MRR	107

File Name	Bit Pos.
LLL	108
ULL	108
DM	109
MR	110
EED	111
EQDYN	111
GPLD	111
SILD	111
USETD	111
LAMA	112
MI	112
OEIGS	112
PHIA	112
PHIG	113
QG	113
OEF1	114
OES1	114
OPHIG	114
OQG1	114
PPHIG	114
BGPDP	115
SIP	115
ELSETS	116
GPSETS	116
PLTPAR	116
PLTSETX	116
MAA	117

3.4.3.3 Card Name Restart Table

Bit Position

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 89	4				12
FILE	1234567890	123456 89	4				12
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	1	3					
CHKPNT	1	3					
TA1	1234567	3					
SAVE	1234567	3					
COND	12345678	34	4				
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4				
SAVE	123 5 78	4	4				
COND	123 5 78	4	4				
CHKPNT	123 5 78	4	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45	4				
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	12					
GP4	1 90	12					
SAVE	1 90	12					
COND	1 90	12					
PURGE	1 90	12					
EQUIV	123456789	4	4				
CHKPNT	1234567890	12 4	4				
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
MCE2	123456789	4	4				
CHKPNT	123456789	4	4				
LABEL	123456789	4	4				
EQUIV	1234567890	4	4				
CHKPNT	1234567890	4	4				
COND	1234567890	4	4				
SCE1	1234567890	4	4				
CHKPNT	1234567890	4	4				
LABEL	1234567890	4	4				
EQUIV	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
COND	1234567890	1 4	4				
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
COND	1234567890	12 4	4				
RBMG1	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
RBMG2	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG3	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG4	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
LABEL	1234567890	12 4	4				
DPD	1 90	12					1
SAVE	1 90	12					1
COND	1 90	12					1
CHKPNT	1 90	12					1
READ	1234567890	12 4	4				12
SAVE	1234567890	12 4	4				12
CHKPNT	1234567890	12 4	4				12
OFP	1234567890	12 4	4				12
SAVE	1234567890	12 4	4				12
COND	1234567890	12 4	4				12
SDR1	1234567890	12 4	4				12
CHKPNT	1234567890	12 4	4				12
PARAM		89					
EQUIV		89					
CHKPNT		89					
COND		89					
PLTTRAN		89					
SAVE		89					
CHKPNT		89					
LABEL		89					
SDR2		89					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
JUMP	1234567890	123456 89	4				12
LABEL	1234567890	123456 89	4				12

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
PRTPARM	1234567890	123456 89	4				12
LABEL	1234567890	123456 89	4				12
PRTPARM	1234567890	123456 89	4				12
LABEL	1234567890	123456 89	4				12
PRTPARM	1234567890	123456 89	4				12
LABEL	1234567890	123456 89	4				12
END	1234567890	123456 89	4				12

3.4.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 ... 70 ... 80
BEGIN	34 678901234
FILE	34 678901234
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
COND	
PURGE	
CHKPNT	
SMA1	
CHKPNT	
SMA2	3 678
SAVE	3 678
COND	34 678901234
CHKPNT	3 678
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
COND	
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	

DMAP Inst.	Bit Position 63 ... 70 ... 80
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
SMP2	
CHKPNT	
LABEL	
COND	
RBMG1	
CHKPNT	
RBMG2	
CHKPNT	
RBMG3	
CHKPNT	
RBMG4	
CHKPNT	
LABEL	
DPD	
SAVE	
COND	34 678901234
CHKPNT	
READ	
SAVE	
CHKPNT	
OFP	
SAVE	
COND	
SDR1	34 678901234
CHKPNT	34 678901234
PARAM	
EQUIV	
CHKPNT	
COND	
PLTTRAN	
SAVE	
CHKPNT	
LABEL	
SDR2	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
JUMP	34 678901234
LABEL	34 678901234

DMAP Inst.	Bit Position 63 70 80
PRTPARM	34 678901234
LABEL	34 678901234
PRTPARM	34 678901234
LABEL	34 678901234
PRTPARM	34 678901234
LABEL	34 678901234
END	34 678901234

3.4.3.5 File Name Restart Table

DMAP Inst.	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117
BEGIN																								
FILE																								
GP1	4																							
SAVE	4																							
CHKPNT	4																							
GP2		5																						
CHKPNT		5																						
PLTSET																							6	
SAVE																							6	
PRTMSG																							6	
SETVAL																							6	
SAVE																							6	
COND																								
PLOT																								
SAVE																								
PRTMSG																								
LABEL																								
CHKPNT																							6	
GP3			6																					
CHKPNT			6																					
TA1,				7																				
SAVE				7																				
COND				7																				
PURGE				7					2															
CHKPNT				7																				
SMA1					8																			
CHKPNT					8																			
SMA2						9																		
SAVE						9																		
COND						9																		
CHKPNT						9																		
COND																								
GPWG																								
OFP																								
SAVE																								
LABEL																								
EQUIV							0																	
CHKPNT							0																	
COND							0																	
SMA3							0																	
CHKPNT							0																	
LABEL							0																	
PARAM								1																
GP4								1																
SAVE								1																
COND								1																
PURGE								1		3		5	6	7		9	0			3				
EQUIV											4													
CHKPNT																								
COND									2															
GPSP									2															
OFP									2															
SAVE									2															
LABEL									2															
COND										3	4													
MCE1										3														
CHKPNT										3														

DMAP Inst.	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117
MCE2											4													
CHKPNT											4													
LABEL										3	4													
EQUIV												5												
CHKPNT												5												
COND												5												
SCE1												5												
CHKPNT												5												
LABEL												5												
EQUIV													6											7
CHKPNT													6											7
COND													6											7
SMP1													6											
CHKPNT													6											
SMP2																								7
CHKPNT																								7
LABEL													6											7
COND														7	8	9	0							
RBMG1														7										
CHKPNT														7										
RBMG2															8									
CHKPNT															8									
RBMG3																9								
CHKPNT																9								
RBMG4																	0							
CHKPNT																	0							
LABEL														7	8	9	0							
DPD																		1						
SAVE																		1						
COND																		1						
CHKPNT																		1						
READ																			2					
SAVE																			2					
CHKPNT																			2					
OFP																			2					
SAVE																			2					
COND																				3	4			
SDR1																				3				
CHKPNT																				3				
PARAM																						5		
EQUIV																						5		
CHKPNT																						5		
COND																						5		
PLTTRAN																						5		
SAVE																						5		
CHKPNT																						5		
LABEL																						5		
SDR2																					4			
OFP																								
SAVE																								
COND																								
PLOT																								
SAVE																								
PRTMSG																								
LABEL																								
JUMP																								
LABEL																								

DMAP Inst.	94	Bit Position 100	110	120
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.4.4 Automatic Output for Normal Mode Analysis

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.

    (1) Two consecutive singularities encountered while performing triangular decomposition.

    (2) Four shift points while tracking a single root.

    (3) All eigenvalues found in the frequency range specified.

    (4) Three times the number of roots estimated in the frequency range have been extracted.

    (5) All eigenvalues that exist in the problem have been found.

    (6) The number of roots desired have been found.

    (7) One or more eigenvalues have been found outside the frequency range specified.

    (8) Insufficient time to find another root.

    (9) Unable to converge

7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the frequency range specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
   (1) Normal termination.
   (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
   (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

3.4.5 Case Control Deck and Parameters for Normal Mode Analysis

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
2. On restart, the current EIGR card controls the eigenvalue extraction, regardless of what calculations were made in the previous execution. Consequently, when making restarts with either the Determinant method or the Inverse Power method, METHØD should be changed

to select an EIGR card that avoids the extraction of previously found eigenvalues. This is particularly important following unscheduled exits due to insufficient time to find all eigenvalues in the range of interest.

3. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

The following output may be requested for Normal Mode Analysis:

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis:

1. <u>GRDPNT</u> - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. <u>WTMASS</u> - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. <u>CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC</u> - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.5 STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.1 DMAP Sequence for Static Analysis with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.4 DIFFERENTIAL STIFFNESS ANALYSIS - SERIES M1 $

  2  FILE     LBLL=TAPE/LLL=TAPE $

  3  FILE     QBG=APPEND/UBGV=APPEND $

  4  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
              123/V,N,NOGPDT $

  5  SAVE     LUSET $

  6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  7  GP2      GEOM2,EQEXIN/ECT $

  8  CHKPNT   ECT $

  9  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT $

 10  SAVE     NSIL,JUMPPLOT $

 11  PRTMSG   PLTSETX// $

 12  SETVAL   //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 13  SAVE     PLTFLG,PFILE $

 14  COND     P1,JUMPPLOT $

 15  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 16  SAVE     JUMPPLOT,PLTFLG,PFILE $

 17  PRTMSG   PLOTX1// $

 18  LABEL    P1 $

 19  CHKPNT   PLTPAR,GPSETS,ELSETS $

 20  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 21  SAVE     NOGRAV $

 22  PARAM    //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

 23  PURGE    MGG/SKPMGG $

 24  CHKPNT   SLT,GPTT,MGG $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 25  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 26  SAVE      NOSIMP,NOGENL,GENEL $

 27  COND      ERROR1,NOSIMP $

 28  PURGE     OGPST/GENEL $

 29  CHKPNT    EST,ECPT,GPCT,GEI,OGPST $

 30  SMA1      CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 31  CHKPNT    GPST,KGGX $

 32  COND      LBL1,SKPMGG $

 33  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
               V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
               Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
               CPTRBSC $

 34  SAVE      NOMGG $

 35  CHKPNT    MGG $

 36  COND      LBL1,GRDPNT $

 37  COND      ERROR4,NOMGG $

 38  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 39  OFP       OGPWG,,,,,//V,N,CARDNO $

 40  SAVE      CARDNO $

 41  LABEL     LBL1 $

 42  EQUIV     KGGX,KGG/NOGENL $

 43  CHKPNT    KGG $

 44  COND      LBL11,NOGENL $

 45  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 46  CHKPNT    KGG $

 47  LABEL     LBL11 $

 48  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 49  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,YS,USET,/V,N,LUSET/V,N,MPCF1/
              V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
              V,N,NOSET/V,N,NOL/V,N,NOA $

 50  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 51  COND     ERROR5,NOL $

 52  PURGE    GM/MPCF1/GO,KOO,LOO,UOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE/
              UBOOV/OMIT/YBS,PBS,KBFS,KBSS,KDFS,KDSS/SINGLE $

 53  EQUIV    KGG,KNN/MPCF1 $

 54  CHKPNT   GM,RG,GO,KOO,LOO,UOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,KNN,UBOOV,
              YBS,PBS,KBFS,KBSS,KDFS,KDSS,QG $

 55  COND     LBL4D,REACT $

 56  JUMP     ERROR2 $

 57  LABEL    LBL4D $

 58  COND     LBL4,GENEL$

 59  GPSP     GPL,GPST,USET,SIL/OGPST $

 60  OFP      OGPST,,,,,//V,N,CARDNO $

 61  SAVE     CARDNO $

 62  LABEL    LBL4 $

 63  COND     LBL2,MPCF2 $

 64  MCE1     USET,RG/GM $

 65  CHKPNT   GM $

 66  MCE2     USET,GM,KGG,,,/KNN,,, $

 67  CHKPNT   KNN $

 68  LABEL    LBL2 $

 69  EQUIV    KNN,KFF/SINGLE $

 70  CHKPNT   KFF $

 71  COND     LBL3,SINGLE $

 72  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73   CHKPNT    KFS,KSS,KFF $

 74   LABEL     LBL3 $

 75   EQUIV     KFF,KAA/OMIT $

 76   CHKPNT    KAA $

 77   COND      LBL5,OMIT $

 78   SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 79   CHKPNT    GO,KAA,KOO,LOO,UOO $

 80   LABEL     LBL5 $

 81   RBMG2     KAA/LLL,ULL $

 82   CHKPNT    ULL,LLL $

 83   SSG1      SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
                LUSET/C,N,1 $

 84   CHKPNT    PG $

 85   EQUIV     PG,PL/NOSET $

 86   CHKPNT    PL $

 87   COND      LBL10,NOSET $

 88   SSG2      USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

 89   CHKPNT    PO,PS,PL $

 90   LABEL     LBL10 $

 91   SSG3      LLL,ULL,KAA,PL,LOO,UOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/ V,Y,
                IRES=-1/V,N,NSKIP/V,N,EPSI $

 92   SAVE      EPSI $

 93   CHKPNT    ULV,UOOV,RULV,RUOV $

 94   COND      LBL9,IRES $

 95   MATGPR    GPL,USET,SIL,RULV//C,N,L $

 96   MATGPR    GPL,USET,SIL,RUOV//C,N,O $

 97   LABEL     LBL9 $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

 98  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              DSO $

 99  CHKPNT   UGV,QG,PGG $

100  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,PGG,QG,UGV,EST,/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,DSO $

101  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

102  SAVE     CARDNO $

103  COND     P2,JUMPPLOT $

104  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,/PLOTX2/V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

105  SAVE     PFILE $

106  PRTMSG   PLOTX2// $

107  LABEL    P2 $

108  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET$

109  SAVE     DSCOSET $

110  CHKPNT   KDGG $

111  EQUIV    KDGG,KDNN/MPCF2 $

112  CHKPNT   KDNN $

113  COND     LBL2D,MPCF2 $

114  MCE2     USET,GM,KDGG,,,/KDNN,,, $

115  CHKPNT   KDNN $

116  LABEL    LBL2D $

117  EQUIV    KDNN,KDFF/SINGLE $

118  CHKPNT   KDFF $

119  COND     LBL3D,SINGLE $

120  SCE1     USET,KDNN,,,/KDFF,KDFS,KDSS,,, $

121  CHKPNT   KDFF,KDFS,KDSS $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

122   LABEL     LBL3D $

123   EQUIV     KDFF,KDAA/OMIT $

124   CHKPNT    KDAA $

125   COND      LBL5D,OMIT $

126   SMP2      USET,GO,KDFF/KDAA $

127   CHKPNT    KDAA $

128   LABEL     LBL5D $

129   EQUIV     PL,PBL/DSCOSET/PS,PBS/DSCOSET/YS,YBS/DSCOSET/UOOV,UBOOV/
                DSCOSET $

130   CHKPNT    PBL,PBS,YBS,UBOOV $

131   PARAM     //C,N,MPY/V,N,NDSKIP/C,N,0/C,N,0 $

132   JUMP      DSLOOP $
                                                        Top of DMAP Loop
133   LABEL     DSLOOP $

134   DSMG2     MPT,KAA,KDAA,KFS,KDFS,KSS,KDSS,PL,PS,YS,UOOV/KBLL,KBFS,KBSS,
                PBL,PBS,YBS,UBOOV/V,N,NDSKIP/ V,N,REPEATD/ V,N,DSCOSET $

135   SAVE      NDSKIP,REPEATD $

136   CHKPNT    KBLL,KBFS,KBSS,PBL,PBS,YBS,UBOOV $

137   RBMG2     KBLL/LBLL,UBLL/V,N,POWER/V,N,DET $

138   SAVE      DET,POWER $

139   CHKPNT    LBLL,UBLL $

140   PRTPARM   //C,N,0/C,N,DET $

141   PRTPARM   //C,N,0/C,N,POWER $

142   SSG3      LBLL,UBLL,KBLL,PBL,,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/
                V,N,EPSI $

143   SAVE      EPSI $

144   CHKPNT    UBLV,RUBLV $

145   COND      LBL9D,IRES $

146   MATGPR    GPL,USET,SIL,RUBLV//C,N,L $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

147  LABEL     LBL9D $

148  SDR1      USET,,UBLV,UBOOV,YBS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/V,N,NDSKIP/
               C,N,DS1 $

149  CHKPNT    UBGV,QBG $

150  COND      LBL8D,REPEATD $

151  REPT      DSLCCP,100 $                                Bottom of DMAP Loop
---------------------------------------------------------------------------
152  JUMP      ERROR3 $

153  PARAM     //C,N,NOT/V,N,TEST/V,N,REPEAT $

154  COND      ERROR6,TEST $

155  LABEL     LBL8D $

156  CHKPNT    CSTM $

157  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,/
               ,OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

158  OFP       OUBGV1,OQBG1,OEFB1,OESB1,,//V,N,CARDNO $

159  SAVE      CARDNO $

160  COND      P3,JUMPPLOT $

161  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUBGV1,/PLOTX3/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

162  SAVE      PFILE $

163  PRTMSG    PLOTX3// $

164  LABEL     P3 $

165  JUMP      FINIS $

166  LABEL     ERROR1 $

167  PRTPARM   //C,N,-1/C,N,DIFFSTIF $

168  LABEL     ERROR2 $

169  PRTPARM   //C,N,-2/C,N,DIFFSTIF $

170  LABEL     ERROR3 $

171  PRTPARM   //C,N,-3/C,N,DIFFSTIF $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 4

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

172  LABEL    ERROR4 $

173  PRTPARM  //C,N,-4/C,N,DIFFSTIF $

174  LABEL    ERROR5 $

175  PRTPARM  //C,N,-5/C,N,DIFFSTIF $

176  LABEL    ERROR6 $

177  PRTPARM  //C,N,-6/C,N,DIFFSTIF $

178  LABEL    FINIS $

179  END      $
```

3.5.2 Description of DMAP Operations for Static Analysis with Differential Stiffness

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

9. PLTSET transforms user input into a form used to drive structure plotter.

11. PRTMSG prints error messages associated with structure plotter.

14. Go to DMAP No. 18 if no undeformed structure plot request.

15. PLØT generates all requested undeformed structure plots.

17. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

20. GP3 generates Static Loads Table and Grid Point Temperature Table.

25. TA1 generates element tables for use in matrix assembly and stress recovery.

27. Go to DMAP No. 166 and print error message if no structural elements.

30. SMA1 generates stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.

32. Go to DMAP No. 41 if no gravity loads and no weight and balance request.

33. SMA2 generates mass matrix $[M_{gg}]$.

36. Go to DMAP No. 41 if no weight and balance request.

37. Go to DMAP No. 172 and print error message if no mass matrix exists.

38. GPWG generates weight and balance information.

39. ØFP formats weight and balance information and places it on the system output file for printing.

42. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.

44. Go to DMAP No. 47 if no general elements.

45. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.

49. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

51. Go to DMAP No. 174 and print error message if no independent degrees of freedom are defined.

53. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

55. Go to DMAP No. 57 if no free-body supports supplied.

56. Go to DMAP No. 168 and print error message if free-body supports are present.

58. Go to DMAP No. 62 if general elements present.

59. GPSP determines if possible grid point singularities remain.

60. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

63. Go to DMAP No. 68 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

64. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

66. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

71. Go to DMAP No. 74 if no single-point constraints.

72. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

77. Go to DMAP No. 80 if no omitted coordinates.

78. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

81. RMBG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$

83. SSG1 generates static load vectors $\{P_g\}$.

85. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

87. Go to DMAP No. 90 if no constraints applied.

88. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ -- \\ P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ -- \\ P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ -- \\ P_o \end{Bmatrix} \quad \text{and} \quad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

91. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{aa}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{aa}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

94. Go to DMAP No. 97 if residual vectors are not to be printed.

95. Print residual vector for independent coordinates (RULV).

96. Print residual vector for omitted coordinates (RUØV).

98. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} \ ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \ , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} \ ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} \ ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \ .$$

100. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, OUGV1, PUGV1, ØQG1).

101. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

103. Go to DMAP No. 107 if no static deformed structure plots are requested.

104. PLØT generates all requested static deformed structure plots.

106. PRTMSG prints plotter data and engineering data for each deformed plot generated.

108. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

111. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

113. Go to DMAP No. 116 if no multipoint constraints.

114. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

117. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.

119. Go to DMAP No. 122 if no single-point constraints.

120. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{array}{c|c} K_{ff}^d & K_{fs}^d \\ \hline K_{sf}^d & K_{ss}^d \end{array}\right] .$$

123. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ if no omitted coordinates.

125. Go to DMAP No. 128 if no omitted coordinates.

126. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

129. Equivalence $\{P_\ell\}$ to $\{P^b_\ell\}$, $\{P_s\}$ to $\{P^b_s\}$, $\{Y_s\}$ to $\{Y^b_s\}$ and $\{u^o_o\}$ to $\{u^{ob}_o\}$ if no scale factors are specified on a DSFACT card.

132. Go to next DMAP instruction if cold start or modified restart. DSLØØP will be altered by the executive System to the proper location inside the loop for unmodified restarts within the loop.

133. Beginning of loop for additional differential stiffness scale factors.

134. DSMG2 adds partitions of stiffness matrix to similar partitions of differential stiffness matrix

$$[K^b_{\ell\ell}] = [K_{aa}] + \beta[K^d_{aa}] \ ,$$

$$[K^b_{fs}] = [K_{fs}] + \beta[K^d_{fs}] \text{ and}$$

$$[K^b_{ss}] = [K_{ss}] + \beta[K^d_{ss}]$$

and multiplies partitions of load vectors and displacement vectors by current value of differential stiffness scale factor (β)

$$\{P^b_\ell\} = \beta\{P_\ell\} \ , \qquad \{P^b_s\} = \beta\{P_s\} \ ,$$

$$\{Y^b_s\} = \beta\{Y_s\} \text{ and } \qquad \{u^{ob}_o\} = \beta\{u^o_o\} \ .$$

137. RMBG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix.

$$[K^b_{\ell\ell}] = [L^b_{\ell\ell}][U^b_{\ell\ell}].$$

140. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

141. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

142. SSG3 solves for displacements of independent coordinates for current value of differential stiffness scale factor (β)

$$\{u^b_\ell\} = [K^b_{\ell\ell}]^{-1}\{P^b_\ell\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current value of differential stiffness load factor

$$\{\delta P_\ell^b\} = \{P_\ell^b\} - [K_{\ell\ell}^b]\{u_\ell^b\} ,$$

$$\varepsilon_\ell^b = \frac{\{u_\ell^b\}^T\{\delta P_\ell^b\}}{\{P_\ell^b\}^T\{u_\ell^b\}}$$

145. Go to DMAP No. 147 if residual vector for current value of differential stiffness load factor is not to be printed.

146. Print residual vector for current value of differential stiffness load factor.

148. SDR1 recovers dependent displacements for current value of differential stiffness scale factor

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} , \qquad \left\{\begin{array}{c} u_\ell^b \\ \hline u_o^b \end{array}\right\} = \{u_f^b\} ,$$

$$\left\{\begin{array}{c} u_f^b \\ \hline Y_s^b \end{array}\right\} = \{u_n^b\} , \qquad \{u_m^b\} = [G_m]\{u_n^b\} ,$$

$$\left\{\begin{array}{c} u_n^b \\ \hline u_m^b \end{array}\right\} = \{u_g^b\}$$

and recovers single-point forces of constraint for current value of differential stiffness scale factor

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} .$$

150. Go to DMAP No. 155 if all differential stiffness scale factors have been processed.

151. Go to DMAP No. 133 if additional differential stiffness scale factors need to be processed.

152. Go to DMAP No. 170 if number of differential stiffness scale factors exceeds 100.

154. Go to DMAP No. 176 and print error message if multiple boundary conditions or load factors are attempted with improper subset.

157. SDR2 calculates element forces and stresses (ØEFB1, ØESB1) and prepares displacement vectors and single-point forces of constraint for output (ØUBGV1, PUBGV1, ØQBG1) for all differential stiffness scale factors.

158. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

160. Go to DMAP No. 164 if no deformed differential stiffness structure plots are requested.

161. PLØT generates all requested deformed differential stiffness structure plots.

163. PRTMSG prints plotter data and engineering data for each deformed plot generated.

165. Go to DMAP No. 178 and make normal exit.

167. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

169. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

171. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

173. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

175. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

177. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 6 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.5.3 Restart Tables for Static Analysis with Differential Stiffness

3.5.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CSHEAR	2	TEMPMX$	8
ADUM2	1	CTETRA	2	AXISYM$	9
ADUM3	1	CTORDRG	2	MPC	9
ADUM4	1	CTRAPRG	2	MPCADD	9
ADUM5	1	CTRBSC	2	MPCAX	9
ADUM6	1	CTRIA1	2	MPC$	9
ADUM7	1	CTRIA2	2	SPC	10
ADUM8	1	CTRIARG	2	SPC1	10
ADUM9	1	CTRMEM	2	SPCADD	10
AXIC	1	CTRPLT	2	SPCAX	10
AXIF	1	CTUBE	2	SPC$	10
CELAS1	1	CTWIST	2	ASET	11
CELAS2	1	CWEDGE	2	ASET1	11
CELAS3	1	PBAR	3	OMIT	11
CELAS4	1	PCONEAX	3	OMIT1	11
CMASS1	1	PDUM1	3	OMITAX	11
CMASS2	1	PDUM2	3	SUPAX	12
CMASS3	1	PDUM3	3	SUPORT	12
CMASS4	1	PDUM4	3	TEMP	13
CORD1C	1	PDUM5	3	TEMPAX	13
CORD1R	1	PDUM6	3	TEMPD	13
CORD1S	1	PDUM7	3	TEMPP1	13
CORD2C	1	PDUM8	3	TEMPP2	13
CORD2R	1	PDUM9	3	TEMPP3	13
CORD2S	1	PQDMEM	3	TEMPRB	13
GRDSET	1	PQDMEM1	3	WTMASS	14
GRID	1	PQDMEM2	3	GRDPNT	15
GRIDB	1	PQDMEM3	3	PLOTEL	16
POINTAX	1	PQDPLT	3	IRES	17
RINGAX	1	PQUAD1	3	PLOT$	18
RINGFL	1	PQUAD2	3	POUT$	19
SECTAX	1	PROD	3	LOOP$	22
SEQGP	1	PSHEAR	3	LOOP1$	23
SPOINT	1	PTORDRG	3	COUPMASS	24
BAROR	2	PTRBSC	3	CPBAR	24
CBAR	2	PTRIA1	3	CPQDPLT	24
CCONEAX	2	PTRIA2	3	CPQUAD1	24
CDUM1	2	PTRMEM	3	CPQUAD2	24
CDUM2	2	PTRPLT	3	CPROD	24
CDUM3	2	PTUBE	3	CPTRBSC	24
CDUM4	2	PTWIST	3	CPTRIA1	24
CDUM5	2	GENEL	4	CPTRIA2	24
CDUM6	2	CONM1	5	CPTRPLT	24
CDUM7	2	CONM2	5	CPTUBE	24
CDUM8	2	PELAS	6	SPCD	56
CDUM9	2	PMASS	7	DSFACT	58
CHEXA1	2	MAT1	8	DSCO$	58
CHEXA2	2	MAT2	8	DEFORM	59
CONROD	2	MAT3	8	DEFORM$	59
CQDMEM	2	MATT1	8	LOAD$	59
CQDMEM1	2	MATT2	8	RFORCE$	59
CQDMEM2	2	MATT3	8	FORCE	60
CQDMEM3	2	TABLEM1	8	FORCE1	60
CQDPLT	2	TABLEM2	8	FORCE2	60
CQUAD1	2	TABLEM3	8	FORCEAX	60
CQUAD2	2	TABLEM4	8	LOAD	60
CROD	2	TEMPMT$	8	MOMAX	60

Card Name	Bit Pos.
MOMENT	60
MOMENT1	60
MOMENT2	60
PLOAD	60
PLOAD1	60
PLOAD2	60
PRESAX	60
SLOAD	60
GRAV	61
RFORCE	61
TEMPLD$	62

3.5.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
SLT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
KNN	104
KFF	105
KFS	105
KSS	105
GO	106
KAA	106
KOO	106
LOO	106
UOO	106
LLL	107
ULL	107
PG	108
PL	109
PO	109
PS	109
RULV	110
RUOV	110
ULV	110
UOOV	110
PGG	111
QG	111
UGV	111
OEF1	112
OES1	112
OPG1	112
OQG1	112
OUGV1	112
PUGV1	112
KDGG	113
KDNN	114
KDFF	115
KDFS	115
KDSS	115
KDAA	116
KBLL	117
KBFS	117
KBSS	117
PBL	117
PBS	117
UBOOV	117
YBS	117
LBLL	118
UBLL	118
UBLV	119
RUBLV	119
QBG	120
UBGV	120
OEFB1	121
OESB1	121
OQBG1	121
OUBGV1	121
PUBGV1	121
ELSETS	122
GPSETS	122
PLTPAR	122
PLTSETX	122

3.5.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456789	234			890	12
FILE	1234567890	123456789	234			890	12
FILE	1234567890	123456789	234			890	12
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	12	3				0	1
SAVE	12	3				0	1
PARAM	12	3 5				0	1
PURGE	12	3 5				0	1
CHKPNT	12	3				0	1
TA1,	1234567	3					
SAVE	1234567	3					
COND	12345678	3					
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
COND	123 5 78	45	4				1
SMA2	123 5 78	4	4				1
SAVE	123 5 78	4	4				1
CHKPNT	123 5 78	4	4				1
COND	123 5 78	45	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45	4				1
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	1					
GP4	1 90	1				6	
SAVE	1 90	1				6	
COND	1 90	1				6	
PURGE	1 90	1				6	
EQUIV	1234 6 89					6	
CHKPNT	1234 6 890	1				6	
COND	1	2					
JUMP	1	2					
LABEL	1	2					

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						
SAVE	123 6 890						
LABEL	123 6 890						
COND	1234 6 89						
MCE1	1 9						
CHKPNT	1 9						
MCE2	1234 6 89						
CHKPNT	1234 6 89						
LABEL	1234 6 89						
EQUIV	1234 6 890						
CHKPNT	1234 6 890						
COND	1234 6 890						
SCE1	1234 6 890						
CHKPNT	1234 6 890						
LABEL	1234 6 890						
EQUIV	1234 6 890	1					
CHKPNT	1234 6 890	1					
COND	1234 6 890	1					
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
LABEL	1234 6 890	1					
RBMG2	1234 6 890	1					
CHKPNT	1234 6 890	1					
SSG1	123 5678					90	12
CHKPNT	123 5678					90	12
EQUIV	123 567890	1				90	12
CHKPNT	123 567890	1				90	12
COND	123 567890	1				90	12
SSG2	123 567890	1				6 90	12
CHKPNT	123 567890	1				6 90	12
LABEL	123 567890	1				6 90	12
SSG3	1234567890	1				6 90	12
SAVE	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
COND	1234567890	1 7				6 90	12
MATGPR	1234567890	1 7				6 90	12
MATGPR	1234567890	1 7				6 90	12
LABEL	1234567890	1 7				6 90	12
SDR1	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
SDR2		9					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
DSMG1	1234567890	1				6 890	12
SAVE	1234567890	1				6 890	12
CHKPNT	1234567890	1				6 90	12
EQUIV	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
COND	1234567890	1				6 90	12
MCE2	1234567890	1				6 90	12

Bit Position

DMAP Inst.	1	10	20	30	40	50	60
CHKPNT	1234567890	1				6 90	12
LABEL	1234567890	1				6 90	12
EQUIV	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
COND	1234567890	1				6 90	12
SCE1	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
LABEL	1234567890	1				6 90	12
EQUIV	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
COND	1234567890	1				6 90	12
SMP2	1234567890	1				6 90	12
CHKPNT	1234567890	1				6 90	12
LABEL	1234567890	1				6 90	12
EQUIV	1234567890	1	23			6 890	12
CHKPNT	1234567890	1	23			6 890	12
PARAM	1234567890	1	23			6 890	12
JUMP			23				
$SS	1 3						
LABEL			23				
$SS	1 3						
DSMG2	1234567890	1	23			6 890	12
SAVE	1234567890	1	23			6 890	12
CHKPNT	1234567890	1	23			6 890	12
RBMG2	1234567890	1	23			6 890	12
SAVE	1234567890	1	23			6 890	12
CHKPNT	1234567890	1	23			6 890	12
PRTPARM	1234567890	1	23			6 890	12
PRTPARM	1234567890	1	23			6 890	12
SSG3	1234567890	1	23			6 890	12
SAVE	1234567890	1	23			6 890	12
CHKPNT	1234567890	1	23			6 890	12
COND	1234567890	1 7	23			6 890	12
MATGPR	1234567890	1 7	23			6 890	12
LABEL	1234567890	1 7	23			6 890	12
SDR1	1234567890	1	23			6 890	12
CHKPNT	1234567890	1	23			6 890	12
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
PARAM			23				
COND			23				
LABEL			23				
$SS	1 3						
CHKPNT		9					
SDR2		89					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
JUMP	1234567890	123456789	234			6 890	12

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

DMAP Inst.	1	10	20	Bit Position 30	40	50	60
LABEL	1234567890	123456789	234				6 890	12
PRTPARM	1234567890	123456789	234				6 890	12
LABEL	1234567890	123456789	234				6 890	12
PRTPARM	1234567890	123456789	234				6 890	12
LABEL	1234567890	123456789	234				6 890	12
$SS	1 3							
PRTPARM	1234567890	123456789	234				6 890	12
$SS	1 3							
LABEL	1234567890	123456789	234				6 890	12
PRTPARM	1234567890	123456789	234				6 890	12
LABEL	1234567890	123456789	234				6 890	12
PRTPARM	1234567890	123456789	234				6 890	12
LABEL	1234567890	123456789	234				6 890	12
PRTPARM	1234567890	123456789	234				6 890	12
LABEL	1234567890	123456789	234				6 890	12
END	1234567890	123456789	234				6 890	12

3.5.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63	70	80
BEGIN	345	78901234	
FILE	345	78901234	
FILE	345	78901234	
GP1			
SAVE			
CHKPNT			
GP2			
CHKPNT			
PLTSET			
SAVE			
PRTMSG			
SETVAL			
SAVE			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
CHKPNT			
GP3			
SAVE			
PARAM			
PURGE			
CHKPNT			
TA1			
SAVE			
COND	345	78901234	
PURGE			
CHKPNT			
SMA1			
CHKPNT			
COND			
SMA2			
SAVE			
CHKPNT			
COND			
COND			
GPWG			
OFP			
SAVE			
LABEL			
EQUIV			
CHKPNT			
COND			
SMA3			
CHKPNT			
LABEL			
PARAM			
GP4			
SAVE			
COND	345	901234	
PURGE			
EQUIV			
CHKPNT			
COND	345	901234	
JUMP	345	901234	
LABEL	345	901234	

DMAP Inst.	Bit Position 63	70	80
COND			
GPSP			
OFP			
SAVE			
LABEL			
COND			
MCE1			
CHKPNT			
MCE2			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
SCE1			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
SMP1			
CHKPNT			
LABEL			
RBMG2			
CHKPNT			
SSG1			
CHKPNT			
EQUIV			
CHKPNT			
COND			
SSG2			
CHKPNT			
LABEL			
SSG3	4		
SAVE	4		
CHKPNT	4		
COND	45	8901234	
MATGPR	45	8901234	
MATGPR	45	8901234	
LABEL	45	8901234	
SDR1			
CHKPNT			
SDR2			
OFP			
SAVE			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
DSMG1			
SAVE			
CHKPNT			
EQUIV			
CHKPNT			
COND			
MCE2			

DMAP Inst.	Bit Position 63	70	80
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
SCE1			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
SMP2			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
PARAM			
JUMP			
LABEL			
DSMG2			
SAVE			
CHKPNT			
PBMG2			
SAVE			
CHKPNT			
PRTPARM			
PRTPARM			
SSG3			
SAVE			
CHKPNT			
COND			
MATGPR			
LABEL			
SDR1	345	78901234	
CHKPNT	345	78901234	
COND	345	78901234	
REPT	345	78901234	
JUMP	345	78901234	
PARAM	345	78901234	
COND	345	78901234	
LABEL	345	78901234	
CHKPNT			
SDR2			
OFP			
SAVE			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
JUMP	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	

Inst.	Bit Position 63	70	80
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
END	345	78901234	

3.5.3.5 File Name Restart Table

DMAP Inst.	Bit Position 94	100	110	120
BEGIN				
FILE				
FILE				
GP1	4			
SAVE	4			
CHKPNT	4			
GP2	5			
CHKPNT	5			
PLTSET				2
SAVE				2
PRTMSG				2
SETVAL				2
SAVE				2
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				2
GP3	6			
SAVE	6			
PARAM	6			
PURGE	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
COND	7 9			
PURGE	7	2		
CHKPNT	7			
SMA1	8			
CHKPNT	8			
COND	9			
SMA2	9			
SAVE	9			
CHKPNT	9			
COND				
COND				
GPWG				
OFP				
SAVE				
LABEL	7 9			
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
COND		1		
PURGE		1 3 56 9	01 5 7	
EQUIV		4		
CHKPNT				
COND				
JUMP				
LABEL				

DMAP Inst.	Bit Position 94	100	110	120
COND		2		
GPSP		2		
OFP		2		
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		
CHKPNT		6		
COND		6		
SMP1		6		
CHKPNT		6		
LABEL		6		
RBMG2		7		
CHKPNT		7		
SSG1		8		
CHKPNT		8		
EQUIV		9		
CHKPNT		9		
COND		9		
SSG2		9		
CHKPNT		9		
LABEL		9		
SSG3			0	
SAVE			0	
CHKPNT			0	
COND				
MATGPR				
MATGPR				
LABEL				
SDR1			1	
CHKPNT			1	
SDR2			2	
OFP				
SAVE				
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
DSMG1			3	
SAVE			3	
CHKPNT			3	
EQUIV			4	
CHKPNT			4	
COND			4	
MCE2			4	

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

DMAP Inst.	Bit Position (94 100 110 120)
CHKPNT	4
LABEL	4
EQUIV	5
CHKPNT	5
COND	5
SCE1	5
CHKPNT	5
LABEL	5
EQUIV	6
CHKPNT	6
COND	6
SMP2	6
CHKPNT	6
LABEL	6
EQUIV	7
CHKPNT	7
PARAM	7
JUMP	
LABEL	
DSMG2	7
SAVE	7
CHKPNT	7
RBMG2	8
SAVE	8
CHKPNT	8
PRTPARM	8
PRTPARM	8
SSG3	9
SAVE	9
CHKPNT	9
COND	
MATGPR	
LABEL	
SDR1	0
CHKPNT	0
COND	
REPT	
JUMP	
PARAM	
COND	
LABEL	
CHKPNT	
SDR2	1
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
JUMP	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
END	

3.5.4 Automatic Output for Static Analysis with Differential Stiffness

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed for each differential stiffness loading condition.

3.5.5 Case Control Deck and Parameters for Static Analysis with Differential Stiffness

The following items relate to subcase definition and data selection for Static Analysis with Differential Stiffness:

1. The Case Control Deck must contain at least two subcases. Other than DSCØEFFICIENT in the second subcase, all subcases are used only for output selection.
2. DSCØEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the default value of unity.
3. A static loading condition must be defined above the subcase level with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.
5. Output requests that apply only to the linear solution must appear in the first subcase.
6. Output requests that apply only to the solution with differential stiffness must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all differential stiffness loading conditions.
7. Output requests that apply to all solutions, both with and without differential stiffness may be placed above the subcase level.

The following output may be requested for Static Analysis with Differential Stiffness:

1. Nonzero Components of the applied static load for the linear solution at selected grid points.
2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.
3. Forces and stresses in selected elements, with and without differential stiffness.

4. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Differential Stiffness:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.6 BUCKLING ANALYSIS

3.6.1 DMAP Sequence for Buckling Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.5 BUCKLING ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

  9  SAVE      NSIL,JUMPPLOT $

 10  PRTMSG    PLTSETX// $

 11  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 12  SAVE      PLTFLG,PFILE $

 13  COND      P1,JUMPPLOT $

 14  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 15  SAVE      JUMPPLOT,PLTFLG,PFILE $

 16  PRTMSG    PLOTX1// $

 17  LABEL     P1 $

 18  CHKPNT    PLTPAR,GPSETS,ELSETS $

 19  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 20  SAVE      NOGRAV $

 21  PARAM     //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

 22  PURGE     MGG/SKPMGG $

 23  CHKPNT    SLT,GPTT,MGG $

 24  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
             123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 25  SAVE    NOSIMP,NOGENL,GENEL $

 26  COND    ERROR1,NOSIMP $

 27  PURGE   OGPST/GENEL $

 28  CHKPNT  EST,ECPT,GPCT,GEI,OGPST $

 29  SMA1    CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 30  CHKPNT  GPST,KGGX $

 31  COND    LBL1,SKPMGG $

 32  SMA2    CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
             V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
             Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
             CPTRBSC $

 33  SAVE    NOMGG $

 34  CHKPNT  MGG $

 35  COND    ERROR5,NOMGG $

 36  COND    LBL1,GRDPNT $

 37  GPWG    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 38  OFP     OGPWG,,,,,//V,N,CARDNO $

 39  SAVE    CARDNO $

 40  LABEL   LBL1 $

 41  EQUIV   KGGX,KGG/NOGENL $

 42  CHKPNT  KGG $

 43  COND    LBL11,NOGENL $

 44  SMA3    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 45  CHKPNT  KGG $

 46  LABEL   LBL11 $

 47  PARAM   //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 48  GP4     CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,YS,USET,/V,N,LUSET/V,N,MPCF1/
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.
                  V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
                  V,N,NOSET/V,N,NOL/V,N,NOA $

 49  SAVE         MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 50  COND         ERROR6,NOA $

 51  PARAM        //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 52  PURGE        GM/MPCF1/GO,KOO,LOO,UOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/
                  QG/NOSR $

 53  EQUIV        KGG,KNN/MPCF1 $

 54  CHKPNT       GM,RG,GO,KOO,LOO,UOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,QG,KNN $

 55  COND         LBL4D,REACT $

 56  JUMP         ERROR2 $

 57  LABEL        LBL4D $

 58  COND         LBL4,GENEL $

 59  GPSP         GPL,GPST,USET,SIL/OGPST $

 60  OFP          OGPST,,,,,//V,N,CARDNO $

 61  SAVE         CARDNO $

 62  LABEL        LBL4 $

 63  COND         LBL2,MPCF2 $

 64  MCE1         USET,RG/GM $

 65  CHKPNT       GM $

 66  MCE2         USET,GM,KGG,,,/KNN,,, $

 67  CHKPNT       KNN $

 68  LABEL        LBL2 $

 69  EQUIV        KNN,KFF/SINGLE $

 70  CHKPNT       KFF $

 71  COND         LBL3,SINGLE $

 72  SCE1         USET,KNN,,,/KFF,KFS,KSS,,, $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  CHKPNT   KFS,KSS,KFF $

 74  LABEL    LBL3 $

 75  EQUIV    KFF,KAA/OMIT $

 76  CHKPNT   KAA $

 77  COND     LBL5,OMIT $

 78  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 79  CHKPNT   GO,KAA,KOO,LOO,UOO $

 80  LABEL    LBL5 $

 81  RBMG2    KAA/LLL,ULL $

 82  CHKPNT   ULL,LLL $

 83  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
              LUSET/C,N,1 $

 84  CHKPNT   PG $

 85  EQUIV    PG,PL/NOSET $

 86  CHKPNT   PL $

 87  COND     LBL10,NOSET $

 88  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

 89  CHKPNT   PO,PS,PL $

 90  LABEL    LBL10 $

 91  SSG3     LLL,ULL,KAA,PL,LOO,UOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/ V,Y,
              IRES=-1/C,N,1/V,N,EPSI $

 92  SAVE     EPSI $

 93  CHKPNT   ULV,UOOV,RULV,RUOV $

 94  COND     LBL9,IRES $

 95  MATGPR   GPL,USET,SIL,RULV//C,N,L $

 96  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

 97  LABEL    LBL9 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 98  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              BKLO $

 99  CHKPNT   UGV,QG,PGG $

100  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,PGG,QG,UGV,EST,/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $

101  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

102  SAVE     CARDNO $

103  COND     P2,JUMPPLOT $

104  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,/PLOTX2/V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

105  SAVE     PFILE $

106  PRTMSG   PLOTX2// $

107  LABEL    P2 $

108  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $

109  CHKPNT   KDGG $

110  EQUIV    KDGG,KDNN/MPCF2 $

111  CHKPNT   KDNN $

112  COND     LBL2D,MPCF2 $

113  MCE2     USET,GM,KDGG,,,/KDNN,,, $

114  CHKPNT   KDNN $

115  LABEL    LBL2D $

116  EQUIV    KDNN,KDFF/SINGLE $

117  CHKPNT   KDFF $

118  COND     LBL3D,SINGLE $

119  SCE1     USET,KDNN,,,/KDFF,KDFS,,,, $

120  CHKPNT   KDFF,KDFS $

121  LABEL    LBL3D $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

122  EQUIV    KDFF,KDAA/OMIT $

123  CHKPNT   KDAA $

124  COND     LBL5D,OMIT $

125  SMP2     USET,GO,KDFF/KDAA $

126  CHKPNT   KDAA $

127  LABEL    LBL5D $

128  ADD      KDAA,/KDAAM/C,N,(-1.0,0.0)/C,N,(0.0,0.0) $

129  CHKPNT   KDAAM $

130  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

131  SAVE     NOEED $

132  COND     ERROR3,NOEED $

133  CHKPNT   EED $

134  READ     KAA,KDAAM,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,BUCKLING/ V,N,
              NEIGV/C,N,2 $

135  SAVE     NEIGV $

136  CHKPNT   LAMA,PHIA,OEIGS $

137  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

138  SAVE     CARDNO $

139  COND     ERROR4,NEIGV $

140  SDR1     USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,BQG/C,N,1/C,N,BKL1 $

141  CHKPNT   PHIG,BQG $

142  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,/ ,
              OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,BKL1 $

143  OFP      OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $

144  SAVE     CARDNO $

145  COND     P3,JUMPPLOT $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 5

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

146  PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG/PLOTX3/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

147  SAVE       PFILE $

148  PRTMSG     PLOTX3// $

149  LABEL      P3 $

150  JUMP       FINIS $

151  LABEL      ERROR1 $

152  PRTPARM    //C,N,-1/C,N,BUCKLING $

153  LABEL      ERROR2 $

154  PRTPARM    //C,N,-2/C,N,BUCKLING $

155  LABEL      ERROR3 $

156  PRTPARM    //C,N,-3/C,N,BUCKLING $

157  LABEL      ERROR4 $

158  PRTPARM    //C,N,-4/C,N,BUCKLING $

159  LABEL      ERROR5 $

160  PRTPARM    //C,N,-5/C,N,BUCKLING $

161  LABEL      ERROR6 $

162  PRTPARM    //C,N,-6/C,N,BUCKLING $

163  LABEL      FINIS $

164  END        $
```

3.6.2 Description of DMAP Operations for Buckling Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

8. PLTSET transforms user input into a form used to drive structure plotter.

10. PRTMSG prints error messages associated with structure plotter.

13. Go to DMAP No. 17 if no undeformed structure plot request.

14. PLØT generates all requested undeformed structure plots.

16. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

19. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 151 and print error message if no structural elements.

29. SMA1 generates stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

31. Go to DMAP No. 40 if no gravity loads and no weight and balance request.

32. SMA2 generates mass matrix $[M_{gg}]$.

35. Go to DMAP No. 159 and print error message if no mass matrix exists.

36. Go to DMAP No. 40 if no weight and balance request.

37. GPWG generates weight and balance information.

38. ØFP formats weight and balance information and places it on the system output file for printing.

41. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

43. Go to DMAP No. 46 if no general elements.

44. SMA3 adds general elements to $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

48. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

50. Go to DMAP No. 161 and print error message if no independent degrees of freedom are defined.

53. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

55. Go to DMAP No. 57 if no free-body supports supplied.

56. Go to DMAP No. 153 and print error message if free-body supports are present.

58. Go to DMAP No. 62 if general elements present.

59. GPSP determines if possible grid point singularities remain.

60. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

63. Go to DMAP No. 68 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

64. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

66. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

71. Go to DMAP No. 74 if no single-point constraints.

72. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

77. Go to DMAP No. 80 if no omitted coordinates.

78. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

81. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

83. SSG1 generates static load vectors $\{P_g\}$.

85. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

87. Go to DMAP No. 90 if no constraints applied.

88. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ \hline P_m\end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ \hline P_s\end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c}P_a \\ \hline P_o\end{array}\right\} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\}$$

91. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\}\ ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

94. Go to DMAP No. 97 if residual vectors are not to be printed.

95. Print residual vector for independent coordinates (RULV)

96. Print residual vector for omitted coordinates (RUØV).

98. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\},$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\},$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

100. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

101. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

103. Go to DMAP No. 107 if no static deformed structure plots are requested.

104. PLØT generates all requested static deformed structure plots.

106. PRTMSG prints plotter data and engineering data for each deformed plot generated.

108. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

110. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

112. Go to DMAP No. 115 if no multipoint constraints.

113. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

116. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.

118. Go to DMAP No. 121 if no single-point constraints.

119. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{array}{c|c} K_{ff}^d & K_{fs}^d \\ \hline K_{sf}^d & K_{ss}^d \end{array}\right]$$

122. Equivalence $[K_{ff}^d]$ to $[K_{aa}^d]$ if no omitted coordinates.

124. Go to DMAP No. 127 if no omitted coordinates.

125. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

130. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

132. Go to DMAP No. 155 and print error message if no Eigenvalue Extraction Data.

134. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell} + \lambda K^d_{\ell\ell}]\{u_\ell\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
  1) Unit value of selected coordinate
  2) Unit value of largest component

137. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

139. Go to DMAP No. 157 and print error message if no eigenvalues found.

140. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} , \qquad \left\{\begin{array}{c} \phi_a \\ \hline \phi_o \end{array}\right\} = \{\phi_f\} ,$$

$$\left\{\begin{array}{c} \phi_f \\ \hline \phi_s \end{array}\right\} = \{\phi_n\} , \qquad \{\phi_m\} = [G_m]\{\phi_n\} ,$$

$$\left\{\begin{array}{c} \phi_n \\ \hline \phi_m \end{array}\right\} = \{\phi_g\}$$

and recovers single point forces of constraint $\{q_s\} = [K^T_{fs}]\{\phi_f\}$.

142. SDR2 calculates element forces and stresses (ØBEF1, ØBES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØBQG1).

143. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

145. Go to DMAP No. 149 if no deformed (buckling) structure plots are requested.

146. PLØT generates all requested deformed (buckling) structure plots.

148. PRTMSG prints plotter data and engineering data for each deformed plot generated.

150. Go to DMAP No. 163 and make normal exit.

152. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

154. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

156. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

158. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUES FØUND.

160. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

162. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.6.3 Restart Tables for Buckling Analysis

3.6.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
AXIC	1
AXIF	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CMASS1	1
CMASS2	1
CMASS3	1
CMASS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
GRDSET	1
GRID	1
GRIDB	1
POINTAX	1
RINGAX	1
RINGFL	1
SECTAX	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CCONEAX	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CHEXA1	2
CHEXA2	2
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQDPLT	2
CQUAD1	2
CQUAD2	2
CROD	2

Card Name	Bit Pos.
CSHEAR	2
CTETRA	2
CTORDRG	2
CTRAPRG	2
CTRBSC	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTRPLT	2
CTUBE	2
CTWIST	2
CWEDGE	2
PBAR	3
PCONEAX	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQDPLT	3
PQUAD1	3
PQUAD2	3
PROD	3
PSHEAR	3
PTORDRG	3
PTRBSC	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTRPLT	3
PTUBE	3
PTWIST	3
GENEL	4
CONM1	5
CONM2	5
PELAS	6
PMASS	7
MAT1	8
MAT2	8
MAT3	8
MATT1	8
MATT2	8
MATT3	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8

Card Name	Bit Pos.
TEMPMX$	8
AXISYM$	9
MPC	9
MPCADD	9
MPCAX	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPCAX	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
OMITAX	11
SUPAX	12
SUPORT	12
TEMP	13
TEMPAX	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
WTMASS	14
GRDPNT	15
PLOTEL	16
IRES	17
PLOT$	18
POUT$	19
COUPMASS	24
CPBAR	24
CPQDPLT	24
CPQUAD1	24
CPQUAD2	24
CPROD	24
CPTRBSC	24
CPTRIA1	24
CPTRIA2	24
CPTRPLT	24
CPTUBE	24
SPCD	56
GRAV	57
RFORCE	57
TEMPLD$	58
DEFORM	59
DEFORM$	59
LOAD$	59
RFORCE$	59
FORCE	60
FORCE1	60
FORCE2	60
FORCEAX	60
LOAD	60
MOMAX	60
MOMENT	60

Card Name	Bit Pos.
MOMENT1	60
MOMENT2	60
PLOAD	60
PLOAD1	60
PLOAD2	60
PRESAX	60
SLOAD	60
EIGB	61
METHOD$	62

3.6.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
SLT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
KNN	104
KFF	105
KFS	105
KSS	105
GO	106
KAA	106
KOO	106
LOO	106
UOO	106
LLL	107
ULL	107
PG	108
PL	109
PO	109
PS	109
RULV	110
RUOV	110
ULV	110
UOOV	110

File Name	Bit Pos.
PGG	111
QG	111
UGV	111
OEF1	112
OES1	112
OPG1	112
OQG1	112
OUGV1	112
PUGV1	112
KDGG	113
KDNN	114
KDFF	115
KDFS	115
KDSS	115
KDAA	116
EED	117
EQDYN	117
GPLD	117
SILD	117
USETD	117
LAMA	118
OEIGS	118
PHIA	118
QG	119
PHIG	119
OBEF1	120
OBES1	120
OBQG1	120
OPHIG	120
PPHIG	120
KDAAM	121
ELSETS	122
GPSETS	122
PLTPAR	122
PLTSETX	122

3.6.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456789	4			7890	12
FILE	1234567890	123456789	4			7890	12
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	12	3				7 0	
SAVE	12	3				7 0	
PARAM	12	3				7 0	
PURGE	12	3				7 0	
CHKPNT	12	3				7 0	
TA1,	1234567	3					
SAVE	1234567	3					
COND	12345678	3					
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
COND	123 5 78	45	4			7	
SMA2	123 5 78	4	4			7	
SAVE	123 5 78	4	4			7	
CHKPNT	123 5 78	4	4			7	
COND	123 5 78	45	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45				7	
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	1				6	
GP4	1 90	1				6	
SAVE	1 90	1				6	
COND	1 90	1				6	
PARAM	1 90	1				6	
PURGE	1 90	1				6	
EQUIV	1234 6-89					6	
CHKPNT	1234 6 890	1				6	
COND	1	2					
JUMP	1	2					
LABEL	1	2					

BUCKLING ANALYSIS

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60
COND	123 6 890					
GPSP	123 6 890					
OFP	123 6 890					
SAVE	123 6 890					
LABEL	123 6 890					
COND	1234 6 89					
MCE1	1 9					
CHKPNT	1 9					
MCE2	1234 6 89					
CHKPNT	1234 6 89					
LABEL	1234 6 89					
EQUIV	1234 6 890					
CHKPNT	1234 6 890					
COND	1234 6 890					
SCE1	1234 6 890					
CHKPNT	1234 6 890					
LABEL	1234 6 890					
EQUIV	1234 6 890	1				
CHKPNT	1234 6 890	1				
COND	1234 6 890	1				
SMP1	1234 6 890	1				
CHKPNT	1234 6 890	1				
LABEL	1234 6 890	1				
RBMG2	1234 6 890	1				
CHKPNT	1234 6 890	1				
SSG1	123 5678					7890
CHKPNT	123 5678					7890
EQUIV	123 567890	1				7890
CHKPNT	123 567890	1				7890
COND	123 567890	1				67890
SSG2	123 567890	1				67890
CHKPNT	123 567890	1				67890
LABEL	123 567890	1				67890
SSG3	1234567890	1				67890
SAVE	1234567890	1				67890
CHKPNT	1234567890	1				67890
COND	1234567890	1 7				67890
MATGPR	1234567890	1 7				67890
MATGPR	1234567890	1 7				67890
LABEL	1234567890	1 7				67890
SDR1	1234567890	1				67890
CHKPNT	1234567890	1				67890
SDR2		9				
OFP		9				
SAVE		9				
COND		8				
PLOT		8				
SAVE		8				
PRTMSG		8				
LABEL		8				
DSMG1	1234567890	1				67890
CHKPNT	1234567890	1				67890
EQUIV	1234567890	1				67890
CHKPNT	1234567890	1				67890
COND	1234567890	1				67890
MCE2	1234567890	1				67890
CHKPNT	1234567890	1				67890

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
LABEL	1234567890	1				67890	
EQUIV	1234567890	1				67890	
CHKPNT	1234567890	1				67890	
COND	1234567890	1				67890	
SCE1	1234567890	1				67890	
CHKPNT	1234567890	1				67890	
LABEL	1234567890	1				67890	
EQUIV	1234567890	1				67890	
CHKPNT	1234567890	1				67890	
COND	1234567890	1				67890	
SMP2	1234567890	1				67890	
CHKPNT	1234567890	1				67890	
LABEL	1234567890	1				67890	
ADD	1234567890	1				67890	
CHKPNT	1234567890	1				67890	
DPD	1234567890	1				67890	1
SAVE	1234567890	1				67890	1
COND	1234567890	1				67890	1
CHKPNT	1234567890	1				67890	1
READ	1234567890	1				67890	12
SAVE	1234567890	1				67890	12
CHKPNT	1234567890	1				67890	12
OFP	1234567890	1				67890	12
SAVE	1234567890	1				67890	12
COND	1234567890	1				67890	12
SDR1	1234567890	1				67890	12
CHKPNT	1234567890	1				67890	12
SDR2		89					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
JUMP	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
PRTPARM	1234567890	123456789	4			67890	12
LABEL	1234567890	123456789	4			67890	12
END	1234567890	123456789	4			67890	12

3.6.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 70 80
BEGIN	3456 8901234
FILE	3456 8901234
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
SAVE	
PARAM	
PURGE	
CHKPNT	
TA1	
SAVE	
COND	3456 8901234
PURGE	
CHKPNT	
SMA1	
CHKPNT	
COND	
SMA2	
SAVE	
CHKPNT	
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
COND	3456 8901234
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	345 901234
JUMP	345 901234
LABEL	345 901234

DMAP Inst.	Bit Position 63 70 80
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
LABEL	
RBMG2	
CHKPNT	
SSG1	
CHKPNT	
EQUIV	
CHKPNT	
COND	
SSG2	
CHKPNT	
LABEL	
SSG3	4
SAVE	4
CHKPNT	4
COND	45 8901234
MATGPR	45 8901234
MATGPR	45 8901234
LABEL	45 8901234
SDR1	
CHKPNT	
SDR2	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
DSMG1	
CHKPNT	
EQUIV	
CHKPNT	
COND	
MCE2	
CHKPNT	

DMAP Inst.	Bit Position 63	70	80
LABEL			
EQUIV			
CHKPNT			
COND			
SCE1			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
SMP2			
CHKPNT			
LABEL			
ADD			
CHKPNT			
DPD			
SAVE			
COND	345	78901234	
CHKPNT			
READ			
SAVE			
CHKPNT			
OFP			
SAVE			
COND			
SDR1	345	78901234	
CHKPNT	345	78901234	
SDR2			
OFP			
SAVE			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
JUMP	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
PRTPARM	345	78901234	
LABEL	345	78901234	
END	345	78901234	

3.6.3.5 File Name Restart Table

DMAP Inst.	Bit Position 94	100	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
CHKPNT	4			
GP2	5			
CHKPNT	5			
PLTSET				2
SAVE				2
PRTMSG				2
SETVAL				2
SAVE				2
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				2
GP3	6			
SAVE	6			
PARAM	6			
PURGE	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
COND	7 9			
PURGE	7	2		
CHKPNT	7			
SMA1	8			
CHKPNT	8			
COND	9			
SMA2	9			
SAVE	9			
CHKPNT	9			
COND				
COND				
GPWG				
OFP				
SAVE				
LABEL	7 9			
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
COND		1		
PARAM		1		
PURGE		1 3 56 9	01	
EQUIV		4		
CHKPNT				
COND				
JUMP				
LABEL				

DMAP Inst.	Bit Position 94	100	110	120
COND		2		
GPSP		2		
OFP		2		
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		
CHKPNT		6		
COND		6		
SMP1		6		
CHKPNT		6		
LABEL		6		
RBMG2		7		
CHKPNT		7		
SSG1		8		
CHKPNT		8		
EQUIV		9		
CHKPNT		9		
COND		9		
SSG2		9		
CHKPNT		9		
LABEL		9		
SSG3			0	
SAVE			0	
CHKPNT			0	
COND				
MATGPR				
MATGPR				
LABEL				
SDR1			1	
CHKPNT			1	
SDR2			2	
OFP				
SAVE				
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
DSMG1			3	
CHKPNT			3	
EQUIV			4	
CHKPNT			4	
COND			4	
MCE2			4	
CHKPNT			4	

DMAP Inst.	114	115	116	117	118	119	120	121
LABEL	4							
EQUIV		5						
CHKPNT		5						
COND		5						
SCE1		5						
CHKPNT		5						
LABEL		5						
EQUIV			6					
CHKPNT			6					
COND			6					
SMP2			6					
CHKPNT			6					
LABEL			6					
ADD								1
CHKPNT								1
DPD				7				
SAVE				7				
COND				7				
CHKPNT				7				
READ					8			
SAVE					8			
CHKPNT					8			
OFP					8			
SAVE					8			
COND						9		
SDR1						9		
CHKPNT						9		
SDR2							0	
OFP								
SAVE								
COND								
PLOT								
SAVE								
PRTMSG								
LABEL								
JUMP								
LABEL								
PRTPARM								
LABEL								
PRTPARM								
LABEL								
PRTPARM								
LABEL								
PRTPARM								
LABEL								
PRTPARM								
LABEL								
PRTPARM								
LABEL								
END								

3.6.4 Automatic Output for Buckling Analysis

The summary of the eigenvalues associated with the buckling modes and the summary of the eigenvalue analysis performed, as described in the Normal Mode Analysis rigid format, are automatically printed.

3.6.5 Case Control Deck and Parameters for Buckling Analysis

The following items relate to subcase definition and data selection for Buckling Analysis:

1. The Case Control Deck must contain at least two subcases. Subcases beyond the second are used only for output selection.
2. METHØD must appear in the second subcase to select an EIGB card from the Bulk Data Deck.
3. A static loading condition must be defined in the first subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level, unless all constraints are specified on GRID cards.
5. Output requests that apply only to the solution under static load must be placed in the first subcase.
6. Output requests that apply to the buckling solution only must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all buckling modes.
7. Output requests that apply to both the static solution and the buckling modes may be placed above the subcase level.

The following output may be requested for Buckling Analysis:

1. Displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for the static analysis.
2. Forces and stresses in selected elements for the static loading condition.
3. Mode shapes and nonzero components of the single-point forces of constraint at selected grid points for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected buckling modes.

The following parameters are used in Buckling Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.7 PIECEWISE LINEAR ANALYSIS

3.7.1 DMAP Sequence for Piecewise Linear Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.6 PIECEWISE LINEAR STATIC ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  FILE      OG1=APPEND/UGV1=APPEND/KGGSUM=SAVE/PGV1=APPEND $

  4  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  5  SAVE      LUSET $

  6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  7  GP2       GEOM2,EQEXIN/ECT $

  8  CHKPNT    ECT $

  9  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

 10  SAVE      NSIL,JUMPPLOT $

 11  PRTMSG    PLTSETX// $

 12  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 13  SAVE      PLTFLG,PFILE $

 14  COND      P1,JUMPPLOT $

 15  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 16  SAVE      JUMPPLOT,PLTFLG,PFILE $

 17  PRTMSG    PLOTX1// $

 18  LABEL     P1 $

 19  CHKPNT    PLTPAR,GPSETS,ELSETS $

 20  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 21  SAVE      NOGRAV $

 22  PARAM     //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

 23  PURGE     MGG/SKPMGG $

 24  CHKPNT    SLT,GPTT,MGG $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 25  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 26  SAVE      NOSIMP,NOGENL,GENEL $

 27  PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

 28  COND      ERROR4,NOELMT $

 29  PURGE     GPST/NOSIMP/OGPST/GENEL $

 30  CHKPNT    EST,ECPT,GPCT,GEI,GPST,OGPST $

 31  COND      LBL1,NOSIMP $

 32  SMA1      CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

 33  CHKPNT    GPST,KGGX $

 34  COND      LBL1,SKPMGG $

 35  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
               V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
               Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
               CPTRBSC $

 36  SAVE      NOMGG $

 37  CHKPNT    MGG $

 38  COND      LBL1,GRDPNT $

 39  COND      ERROR3,NOMGG $

 40  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 41  OFP       OGPWG,,,,,//V,N,CARDNO $

 42  SAVE      CARDNO $

 43  LABEL     LBL1 $

 44  PLA1      CSTM,MPT,ECPT,GPCT,DIT,CASECC,EST/KGGXL,ECPTNL,ESTL,ESTNL/V,N,
               KGGLPG/V,N,NPLALIM/V,N,ECPTNLPG/V,N,PLSETNO/V,N,NONLSTR/V,N,
               PLFACT $

 45  SAVE      KGGLPG,NPLALIM,ECPTNLPG,PLSETNO,NONLSTR,PLFACT $

 46  COND      ERROR1,ECPTNLPG $

 47  PURGE     ONLES,ESTNL1/NONLSTR $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

```
       N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48  CHKPNT   KGGXL,ECPTNL,ESTL,ESTNL,ESTNL1 $

 49  PARAM    //C,N,ADD/V,N,ALWAYS/C,N,-1/C,N,0 $

 50  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

 51  EQUIV    KGGX,KGG/NOGENL/KGGXL,KGGL/NOGENL $

 52  CHKPNT   KGG,KGGL $

 53  COND     LBL11,NOGENL $

 54  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 55  CHKPNT   KGG $

 56  SMA3     GEI,KGGXL/KGGL/V,N,LUSET/V,N,NOGENL/V,N,KGGLPG $

 57  CHKPNT   KGGL $

 58  LABEL    LBL11 $

 59  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 60  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,YS,USET,/V,N,LUSET/V,N,MPCF1/
              V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
              V,N,NOSET/V,N,NOL/V,N,NOA $

 61  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

 62  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

 63  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,UOO,PO,UOOV,RUOV/OMIT/
              PS,KFS,KSS/SINGLE/QG/NOSR $

 64  EQUIV    KGG,KNN/MPCF1 $

 65  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,UOO,PO,UOOV,QG,PS,KFS,KSS,USET,
              RG,YS,RUOV,KNN $

 66  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,,,MGG,CASECC,DIT/PG1/V,N,   LUSET/C,
              N,1 $

 67  CHKPNT   PG1 $

 68  EQUIV    PG1,PL/NOSET $

 69  CHKPNT   PL $

 70  COND     LBL4,GENEL $

 71  GPSP     GPL,GPST,USET,SIL/OGPST $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 72   OFP      OGPST,,,,,//V,N,CARDNO $

 73   SAVE     CARDNO $

 74   LABEL    LBL4 $

 75   PARAM    //C,N,ADD/V,N,PLACOUNT/C,N,1/C,N,0 $

 76   COND     LBL2,MPCF2 $

 77   MCE1     USET,RG/GM $

 78   CHKPNT   GM $

 79   JUMP     LOOPBGN $
                                                   Top of DMAP Loop
 80   LABEL    LOOPBGN $

 81   EQUIV    KGG,KNN/MPCF2 $

 82   CHKPNT   KNN $

 83   COND     LBL2,MPCF2 $

 84   MCE2     USET,GM,KGG,,,/KNN,,, $

 85   CHKPNT   KNN $

 86   LABEL    LBL2 $

 87   EQUIV    KNN,KFF/SINGLE $

 88   CHKPNT   KFF $

 89   COND     LBL3,SINGLE $

 90   SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $

 91   CHKPNT   KFS,KSS,KFF $

 92   LABEL    LBL3 $

 93   EQUIV    KFF,KAA/OMIT $

 94   CHKPNT   KAA $

 95   COND     LBL5,OMIT $

 96   SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 97   CHKPNT   GO,KAA,KOO,LOO,UOO $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 98  LABEL     LBL5 $

 99  EQUIV     KAA,KLL/REACT $

100  CHKPNT    KLL $

101  COND      LBL6,REACT $

102  RBMG1     USET,KAA,/KLL,KLR,KRR,,, $

103  CHKPNT    KLL,KLR,KRR $

104  LABEL     LBL6 $

105  DECOMP    KLL/LLL,ULL/C,N,1/C,N,0/V,N,MINDIAGK/V,N,DETKLLXX/V,N,IDETKLLX/
               V,N,SINGKLLX $

106  SAVE      SINGKLLX $

107  COND      LOOPENDA,SINGKLLX $

108  CHKPNT    ULL,LLL $

109  COND      LBL7,REACT $

110  RBMG3     LLL,ULL,KLR,KRR/DM $

111  CHKPNT    DM $

112  LABEL     LBL7 $

113  ADD       PG1,/PG/V,N,PLFACT $

114  CHKPNT    PG $

115  COND      LBL10,NOSET $

116  SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $

117  CHKPNT    QR,PO,PS,PL $

118  LABEL     LBL10 $

119  SSG3      LLL,ULL,KLL,PL,LOO,UOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/ V,Y,
               IRES=-1/V,N,PLACOUNT/V,N,EPSI $

120  SAVE      EPSI $

121  CHKPNT    ULV,UOOV,RULV,RUOV $

122  COND      LBL9,IRES $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

123  MATGPR   GPL,USET,SIL,RULV//C,N,L $

124  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

125  LABEL    LBL9 $

126  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/DELTAUGV,DELTAPG,
              DELTAQG/C,N,1/C,N,STATICS $

127  CHKPNT   DELTAUGV,DELTAPG,DELTAQG $

128  PLA2     DELTAUGV,DELTAPG,DELTAQG/UGV1,PGV1,QG1/V,N,PLACOUNT $

129  SAVE     PLACOUNT $

130  CHKPNT   UGV1,QG1,PGV1 $

131  EQUIV    ESTNL,ESTNL1/NEVER/ECPTNL,ECPTNL1/NEVER $

132  COND     PLALBL2A,NONLSTR $

133  PLA3     CSTM,MPT,DIT,DELTAUGV,ESTNL,CASECC/ONLES,ESTNL1/V,N,PLACOUNT/
              V,N,PLSETNO $

134  CHKPNT   ESTNL1 $

135  OFP      ONLES,,,,,//V,N,CARDNO $

136  SAVE     CARDNO $

137  LABEL    PLALBL2A $

138  PARAM    //C,N,SUB/V,N,DIFF/V,N,NPLALIM/V,N,PLACOUNT $

139  COND     LOOPEND,DIFF $

140  PLA4     CSTM,MPT,ECPTNL,GPCT,DIT,DELTAUGV/KGGNL,ECPTNL1/V,N,PLACOUNT/V,
              N,PLSETNO/V,N,PLFACT $

141  SAVE     PLACOUNT,PLSETNO,PLFACT $

142  CHKPNT   KGGNL,ECPTNL1 $

143  EQUIV    KGGNL,KGGSUM/KGGLPG $

144  CHKPNT   KGGSUM $

145  COND     PLALBL3,KGGLPG $

146  ADD      KGGNL,KGGL/KGGSUM $

147  CHKPNT   KGGSUM $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

```
        N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

148  LABEL     PLALBL3 $

149  EQUIV     KGGSUM,KGG/ALWAYS $

150  CHKPNT    KGG $

151  EQUIV     ESTNL1,ESTNL/ALWAYS/ECPTNL1,ECPTNL/ALWAYS $

152  CHKPNT    ESTNL,ECPTNL $

153  COND      PLALBL4,ALWAYS $

154  PLA2      KGGSUM,KGG,/,,/C,N,0 $

155  PLA2      ESTNL1,ECPTNL1,/,,/C,N,0 $

156  LABEL     PLALBL4 $

157  REPT      LOOPBGN,100 $
------------------------------------------------------- Bottom of DMAP Loop
158  JUMP      ERROR2 $

159  LABEL     LOOPENDA $

160  PRTPARM   //C,N,+5/C,N,PLA $

161  LABEL     LOOPEND $

162  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,PGV1,QG1,UGV1,
               ESTL,/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,PLA $

163  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

164  SAVE      CARDNO $

165  COND      P2,JUMPPLOT $

166  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,/PLOTX2/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

167  SAVE      PFILE $

168  PRTMSG    PLOTX2// $

169  LABEL     P2 $

170  JUMP      FINIS $

171  LABEL     ERROR1 $

172  PRTPARM   //C,N,-1/C,N,PLA $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 6

```
   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

173  LABEL     ERROR2 $

174  PRTPARM   //C,N,-2/C,N,PLA $

175  LABEL     ERROR3 $

176  PRTPARM   //C,N,-3/C,N,PLA $

177  LABEL     ERROR4 $

178  PRTPARM   //C,N,-4/C,N,PLA $

179  LABEL     FINIS $

180  END       $
```

3.7.2 Description of DMAP Operations for Piecewise Linear Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

9. PLTSET transforms user input into a form used to drive structure plotter.

11. PRTMSG prints error messages associated with structure plotter.

14. Go to DMAP No. 18 if no undeformed structure plot request.

15. PLØT generates all requested undeformed structure plots.

17. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

20. GP3 generates Static Loads Table and Grid Point Temperature Table.

25. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 177 and print error message if no elements have been defined.

31. Go to DMAP No. 43 if there are no structural elements.

32. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

34. Go to DMAP No. 43 if no gravity loads and no weight and balance request.

35. SMA2 generates mass matrix $[M_{gg}]$.

38. Go to DMAP No. 43 if no weight and balance request.

39. Go to DMAP No. 175 and print error message if no mass matrix exists.

40. GPWG generates weight and balance information.

41. ØFP formats weight and balance information and places it on the system output file for printing.

44. PLA1 extracts the linear terms from $[K^x_{gg}]$ to give $[K^{x\ell}_{gg}]$, extracts the nonlinear entries from the Element Connection and Properties Table to give ECPTNL, and separates the linear and nonlinear entries in the Element Summary Table to give ESTL and ESTNL.

46. Go to DMAP No. 171 and print error message if no elements have a stress dependent modulus of elasticity.

51. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ and $[K^{x\ell}_{gg}]$ to $[K^{\ell}_{gg}]$ if no general elements.

53. Go to DMAP No. 58 if no general elements.

54. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

56. SMA3 adds general elements to $[K^{x\ell}_{gg}]$ to obtain stiffness matrix of linear elements $[K^{\ell}_{gg}]$.

60. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

64. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

66. SSG1 generates total static load vector $\{P^1_g\}$.

68. Equivalence $\{P_g^1\}$ to $\{P_\ell\}$ if no constraints applied.

70. Go to DMAP No. 74 if general elements present.

71. GPSP determines if possible grid point singularities remain.

72. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

76. Go to DMAP No. 86 if no multipoint constraints.

77. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

80. Beginning of loop for Piecewise Linear Analysis.

81. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

83. Go to DMAP No. 86 if no multipoint constraints.

84. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

87. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

89. Go to DMAP No. 92 if no single-point constraints.

90. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

93. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Go to DMAP No. 98 if no omitted coordinates.

96. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

99. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

101. Go to DMAP No. 104 if no free-body supports.

102. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right]$$

105. DECØMP decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

107. Go to DMAP No. 159 if stiffness matrix $[K_{\ell\ell}]$ is singular (i.e., local plasticity).

109. Go to DMAP No. 112 if no free-body supports.

110. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

113. Multiply total load vector $\{P_g^1\}$ by factor to obtain applied load vector $\{P_g\}$ for current loop.

115. Go to DMAP No. 118 if no constraints applied.

116. SSG2 applies constraints to static load vector for current loop.

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates incremental determinate forces of reaction for current loop

$$\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}.$$

119. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}}$$

122. Go to DMAP No. 125 if residual vectors are not to be printed.

123. Print residual vector for independent coordinates (RULV)

124. Print residual vector for omitted coordinates (RUØV).

126. SDR1 recovers dependent incremental displacements for current loop

$$\left\{\begin{matrix} u_\ell \\ -- \\ u_r \end{matrix}\right\} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\},$$

$$\left\{\begin{matrix} u_a \\ -- \\ u_o \end{matrix}\right\} = \{u_f\} , \qquad \left\{\begin{matrix} u_f \\ -- \\ Y_s \end{matrix}\right\} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \left\{\begin{matrix} u_n \\ -- \\ u_m \end{matrix}\right\} = \{u_g\} ,$$

and recovers incremental single-point forces of constraint for current loop

$$\{\delta q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} .$$

128. PLA2 adds the incremental displacement vector and the incremental single-point forces of constraint vector for the current loop to the accumulated sum of these vectors.

$$\{u_{g_{i+1}}\} = \{\delta u_{g_i}\} + \{u_{g_i}\} \quad \text{and}$$

$$\{q_{g_{i+1}}\} = \{\delta q_{g_i}\} + \{q_{g_i}\}$$

131. Allocate separate files for ESTNL and ESTNL1 and for ECPTNL and ECPTNL1.

132. Go to DMAP No. 137 if no stress output requested for nonlinear elements.

133. PLA3 calculates incremental stresses in nonlinear elements for which an output request has been made and updates the accumulated stresses in these elements.

135. ØFP formats the accumulated stresses in nonlinear elements and places them on the system output file for printing.

139. Go to DMAP No. 161 if all loading increments have been completed.

140. PLA4 generates stiffness matrix for nonlinear elements and updates stress information in ECPTNL.

143. Equivalence $[K^{n\ell}_{gg}]$ to $[K_{gg}]$ if all elements are nonlinear.

145. Go to DMAP No. 148 if all elements are nonlinear.

146. Add stiffness matrix for nonlinear elements to stiffness matrix for linear elements

$$[K^{n\ell}_{gg}] + [K^{\ell}_{gg}] \;=\; \mathrm{KGGSUM}$$

149. Equivalence KGGSUM to $[K_{gg}]$ for next pass through loop.

151 Equivalence existing element tables to updated tables for next pass through loop.

153. Go to DMAP No. 156 - next two instructions are never executed.

154. PLA2 is used to define KGGSUM.

155. PLA2 is used to define ESTNL1 and ECPTNL1.

157. Go to DMAP No. 80 if additional load increments need to be processed.

158. Go to DMAP No. 173 and print error message if more than 100 loops.

159. End of loop for Piecewise Linear Analysis when local plasticity occurs in $K_{\ell\ell}$.

160. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

161. End of loop for Piecewise Linear Analysis.

162. SDR2 calculates element forces and stresses for linear elements (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).

163. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

165. Go to DMAP No. 169 if no deformed structure plots are requested.

166. PLØT generates all requested deformed structure plots.

168. PRTMSG prints plotter data and engineering data for each deformed plot generated.

170. Go to DMAP No. 179 and make normal exit.

172. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

174. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

176. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

178. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

3.7.3 Restart Tables for Piecewise Linear Analysis

3.7.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CSHEAR	2	TABLEM4	8
ADUM2	1	CTETRA	2	TABLES1	8
ADUM3	1	CTORDRG	2	TABLES2	8
ADUM4	1	CTRAPRG	2	TABLES3	8
ADUM5	1	CTRBSC	2	TABLES4	8
ADUM6	1	CTRIA1	2	TEMPMT$	8
ADUM7	1	CTRIA2	2	TEMPMX$	8
ADUM8	1	CTRIARG	2	AXISYM$	9
ADUM9	1	CTRMEM	2	MPC	9
AXIC	1	CTRPLT	2	MPCADD	9
AXIF	1	CTUBE	2	MPCAX	9
CELAS1	1	CTWIST	2	MPC$	9
CELAS2	1	CWEDGE	2	SPC	10
CELAS3	1	PBAR	3	SPC1	10
CELAS4	1	PCONEAX	3	SPCADD	10
CMASS1	1	PDUM1	3	SPCAX	10
CMASS2	1	PDUM2	3	SPC$	10
CMASS3	1	PDUM3	3	ASET	11
CMASS4	1	PDUM4	3	ASET1	11
CORD1C	1	PDUM5	3	OMIT	11
CORD1R	1	PDUM6	3	OMIT1	11
CORD1S	1	PDUM7	3	OMITAX	11
CORD2C	1	PDUM8	3	SUPAX	12
CORD2R	1	PDUM9	3	SUPORT	12
CORD2S	1	PQDMEM	3	TEMP	13
GRDSET	1	PQDMEM1	3	TEMPAX	13
GRID	1	PQDMEM2	3	TEMPD	13
GRIDB	1	PQDMEM3	3	TEMPP1	13
POINTAX	1	PQDPLT	3	TEMPP2	13
RINGAX	1	PQUAD1	3	TEMPP3	13
RINGFL	1	PQUAD2	3	TEMPRB	13
SECTAX	1	PROD	3	WTMASS	14
SEQGP	1	PSHEAR	3	GRDPNT	15
SPOINT	1	PTORDRG	3	PLOTEL	16
BAROR	2	PTRBSC	3	IRES	17
CBAR	2	PTRIA1	3	PLOT$	18
CCONEAX	2	PTRIA2	3	POUT$	19
CDUM1	2	PTRMEM	3	LOOP$	22
CDUM2	2	PTRPLT	3	LOOP1$	23
CDUM3	2	PTUBE	3	COUPMASS	24
CDUM4	2	PTWIST	3	CPBAR	24
CDUM5	2	GENEL	4	CPROD	24
CDUM6	2	CONM1	5	CPQDPLT	24
CDUM7	2	CONM2	5	CPQUAD1	24
CDUM8	2	PELAS	6	CPQUAD2	24
CDUM9	2	PMASS	7	CPROD	24
CHEXA1	2	MAT1	8	CPTRBSC	24
CHEXA2	2	MAT2	8	CPTRIA1	24
CONROD	2	MAT3	8	CPTRIA2	24
CQDMEM	2	MATS1	8	CPTRPLT	24
CQDMEM1	2	MATS2	8	CPTUBE	24
CQDMEM2	2	MATT1	8	SPCD	56
CQDMEM3	2	MATT2	8	PLCO$	58
CQDPLT	2	MATT3	8	PLFACT	58
CQUAD1	2	TABLEM1	8	DEFORM	59
CQUAD2	2	TABLEM2	8	DEFORM$	59
CROD	2	TABLEM3	8	LOAD$	59

Card Name	Bit Pos.
RFORCE$	59
FORCE	60
FORCE1	60
FORCE2	60
FORCEAX	60
LOAD	60
MOMAX	60
MOMENT	60
MOMENT1	60
MOMENT2	60
PLOAD	60
PLOAD1	60
PLOAD2	60
PRESAX	60
SLOAD	60
GRAV	61
RFORCE	61
TEMPLD$	62

3.7.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
SLT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGGXL	100
ECPTNL	100
ESTL	100
ESTNL	100
KGG	101
KGGL	101
RG	102
USET	102
YS	102
PG1	103
OGPST	104
GM	105
KNN	106
KFF	107
KFS	107
KSS	107
GO	108
KAA	108
KOO	108
LOO	108
UOO	108

File Name	Bit Pos.
KLL	109
KLR	109
KRR	109
LLL	110
ULL	110
QM	111
PG	112
PL	113
PO	113
PS	113
QR	113
RULV	114
RUOV	114
ULV	114
UOOV	114
PGG	115
DELTAQG	115
DELTAUGV	115
UGV1	116
QG1	116
ONLES	117
ESTNL1	117
KGGNL	118
ECPTNL1	118
KGGSUM	119
OEF1	120
OES1	120
OPG1	120
OQG1	120
OUGV1	120
PUGV1	120
ELSETS	121
GPSETS	121
PLTPAR	121
PLTSETX	121

3.7.3.3 Card Name Restart Table

```
DMAP                                  Bit Position
Inst.      1        10        20        30        40        50        60

BEGIN     1234567890|123456789 | 234      |          |          |       890|12
FILE      1234567890|123456789 | 234      |          |          |       890|12
FILE      1234567890|123456789 | 234      |          |          |       890|12
GP1       1         |          |          |          |          |          |
SAVE      1         |          |          |          |          |          |
CHKPNT    1         |          |          |          |          |          |
GP2       12 45     |     6    |          |          |          |          |
CHKPNT    12 45     |     6    |          |          |          |          |
PLTSET              |       8  |          |          |          |          |
SAVE                |       8  |          |          |          |          |
PRTMSG              |       8  |          |          |          |          |
SETVAL              |       8  |          |          |          |          |
SAVE                |       8  |          |          |          |          |
COND                |       8  |          |          |          |          |
PLOT                |       8  |          |          |          |          |
SAVE                |       8  |          |          |          |          |
PRTMSG              |       8  |          |          |          |          |
LABEL               |       8  |          |          |          |          |
CHKPNT              |       8  |          |          |          |          |
GP3       12        |  3       |          |          |          |         0|1
SAVE      12        |  3       |          |          |          |         0|1
PARAM     12        |  3 5     |          |          |          |         0|1
PURGE     12        |  3 5     |          |          |          |         0|1
CHKPNT              |          |          |          |          |          |
TA1       1234567   |  3       |          |          |          |          |
SAVE      1234567   |  3       |          |          |          |          |
PARAM     1234567   |  3       |          |          |          |          |
COND      1234567   |  3       |          |          |          |          |
PURGE     1234567   |  3       |          |          |          |          |
CHKPNT    1234567   |  3       |          |          |          |          |
COND      123 5678  |   45     |   4      |          |          |          |1
SMA1      123  6 8  |          |          |          |          |          |
CHKPNT    123  6 8  |          |          |          |          |          |
COND      123 5 78  |   45     |   4      |          |          |          |1
SMA2      123 5 78  |   45     |   4      |          |          |          |1
SAVE      123 5 78  |   45     |   4      |          |          |          |1
CHKPNT    123 5 78  |   45     |   4      |          |          |          |1
COND      123 5 78  |   45     |   4      |          |          |          |
COND      123 5 78  |   45     |   4      |          |          |          |
GPWG      123 5 78  |   45     |   4      |          |          |          |
OFP       123 5 78  |   45     |   4      |          |          |          |
SAVE      123 5 78  |   45     |   4      |          |          |          |
LABEL     123 5 78  |   45     |   4      |          |          |          |1
PLA1      123  6 8  |          |          |          |          |          |
SAVE      123  6 8  |          |          |          |          |          |
COND      123  6 8  |          |          |          |          |          |
PURGE     123  6 8  |          |          |          |          |          |
CHKPNT    123  6 8  |          |          |          |          |          |
PARAM     123  6 8  |          |          |          |          |          |
PARAM     123  6 8  |          |          |          |          |          |
EQUIV     1234 6 8  |          |          |          |          |          |
CHKPNT    1234 6 8  |          |          |          |          |          |
COND      1234 6 8  |          |          |          |          |          |
SMA3      1234 6 8  |          |          |          |          |          |
CHKPNT    1234 6 8  |          |          |          |          |          |
SMA3      1234 6 8  |          |          |          |          |          |
CHKPNT    1234 6 8  |          |          |          |          |          |
```

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
LABEL	1234 6 8						
PARAM	1 90	12					
GP4	1 90	12				6	
SAVE	1 90	12				6	
PARAM	1 90	12				6	
PURGE	1 90	12				6	
EQUIV	1234 6 89		23			6	
CHKPNT	1234 6 890	12	23			6	
SSG1	123 5678					90	12
CHKPNT	123 5678					90	12
EQUIV	123 5678					90	12
CHKPNT	123 5678					90	12
COND	123 6 890						
GPSP	123 6 890						
DFP	123 6 890						
SAVE	123 6 890						
LABEL	123 6 890						
PARAM			23				
COND	1234 6 89						
MCE1	1 9						
CHKPNT	1 9						
JUMP			23				
LABEL	1234 6 89		23				
EQUIV	1234 6 89		23				
CHKPNT	1234 6 89		23				
COND	1234 6 89		23				
MCE2	1234 6 89		23				
CHKPNT	1234 6 89		23				
LABEL	1234 6 89		23				
EQUIV	1234 6 890		23				
CHKPNT	1234 6 890		23				
COND	1234 6 890		23				
SCE1	1234 6 890		23				
CHKPNT	1234 6 890		23				
LABEL	1234 6 890		23				
EQUIV	1234 6 890	1	23				
CHKPNT	1234 6 890	1	23				
COND	1234 6 890	1	23				
SMP1	1234 6 890	1	23				
CHKPNT	1234 6 890	1	23				
LABEL	1234 6 890	1	23				
EQUIV	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
COND	1234 6 890	12	23				
RBMG1	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
LABEL	1234 6 890	12	23				
DECOMP	1234 6 890	12	23				
SAVE	1234 6 890	12	23				
COND	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
COND	1234 6 890	12	23				
RBMG3	1234 6 890	12	23				
CHKPNT	1234 6 890	12	23				
LABEL	1234 6 890	12	23				
ADD	123 5678		23			890	12
CHKPNT	123 5678		23			890	12

DMAP Inst.	Bit Position: 1 ... 10	20	30	40	50	60	
COND	123 567890	12	23			6 890	12
SSG2	123 567890	12	23			6 890	12
CHKPNT	123 567890	12	23			6 890	12
LABEL	123 567890	12	23			6 890	12
SSG3	1234567890	12	23			6 890	12
SAVE	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
COND	1234567890	12 7	23			6 890	12
MATGPR	1234567890	12 7	23			6 890	12
MATGPR	1234567890	12 7	23			6 890	12
LABEL	1234567890	12 7	23			6 890	12
SDR1	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
PLA2	1234567890	12	23			6 890	12
SAVE	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
EQUIV	1234567890	12	23			6 890	12
COND			23				
PLA3			23				
CHKPNT			23				
OFP			23				
SAVE			23				
LABEL			23				
PARAM	1234567890	12	23			6 890	12
COND	1234567890	12	23			6 890	12
PLA4	1234567890	12	23			6 890	12
SAVE	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
EQUIV	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
COND	1234567890	12	23			6 890	12
ADD	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
LABEL	1234567890	12	23			6 890	12
EQUIV	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
EQUIV	1234567890	12	23			6 890	12
CHKPNT	1234567890	12	23			6 890	12
COND	1234567890	12	23			6 890	12
PLA2	1234567890	12	23			6 890	12
PLA2	1234567890	12	23			6 890	12
LABEL	1234567890	12	23			6 890	12
REPT	1234567890	12	23			6 890	12
JUMP	1234567890	12	23			6 890	12
LABEL	1234 6 890	12	23				
PRTPARM	1234 6 890	12	23				
LABEL	1234567890	12	23			6 890	12
SDR2		89					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
JUMP	1234567890	123456789	234			6 890	12
LABEL	1234567890	123456789	234			6 890	12

PIECEWISE LINEAR ANALYSIS

DMAP Inst.	Bit Position: 1	10	20	30	40	50	60
PRTPARM	1234567890	123456789	234				6 890 12
LABEL	1234567890	123456789	234				6 890 12
PRTPARM	1234567890	123456789	234				6 890 12
LABEL	1234567890	123456789	234				6 890 12
PRTPARM	1234567890	123456789	234				6 890 12
LABEL	1234567890	123456789	234				6 890 12
PRTPARM	1234567890	123456789	234				6 890 12
LABEL	1234567890	123456789	234				6 890 12
END	1234567890	123456789	234				6 890 12

3.7.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position (63 · 70 · 80)
BEGIN	34567 901234
FILE	34567 901234
FILE	34567 901234
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
SAVE	
PARAM	
PURGE	
CHKPNT	
TA1,	
SAVE	
PARAM	34567 901234
COND	34567 901234
PURGE	
CHKPNT	
COND	
SMA1	
CHKPNT	
COND	
SMA2	
SAVE	
CHKPNT	
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
PLA1	
SAVE	
COND	
PURGE	
CHKPNT	
PARAM	
PARAM	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
SMA3	
CHKPNT	

DMAP Inst.	Bit Position (63 · 70 · 80)
LABEL	
PARAM	
GP4	
SAVE	
PARAM	
PURGE	
EQUIV	
CHKPNT	
SSG1	
CHKPNT	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
PARAM	
COND	
MCE1	
CHKPNT	
JUMP	
LABEL	
EQUIV	
CHKPNT	
COND	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
RBMG1	
CHKPNT	
LABEL	
DECOMP	
SAVE	
COND	
CHKPNT	
COND	
RBMG3	
CHKPNT	
LABEL	
ADD	34 67
CHKPNT	34 67

DMAP Inst.	Bit Position 63 – 70 – 80
COND	34 67
SSG2	34 67
CHKPNT	34 67
LABEL	34 67
SSG3	34 67
SAVE	34 67
CHKPNT	34 67
COND	34567 901234
MATGPR	34567 901234
MATGPR	34567 901234
LABEL	34567 901234
SDR1	34567 901234
CHKPNT	34567 901234
PLA2	
SAVE	
CHKPNT	
EQUIV	
COND	
PLA3	
CHKPNT	
OFP	
SAVE	
LABEL	
PARAM	
COND	
PLA4	
SAVE	
CHKPNT	
EQUIV	
CHKPNT	
COND	
ADD	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
EQUIV	
CHKPNT	
COND	
PLA2	
PLA2	
LABEL	
REPT	
JUMP	
LABEL	
PRTPARM	
LABEL	
SDR2	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
JUMP	34567 901234
LABEL	34567 901234

DMAP Inst.	Bit Position 63 – 70 – 80
PRTPARM	34567 901234
LABEL	34567 901234
PRTPARM	34567 901234
LABEL	34567 901234
PRTPARM	34567 901234
LABEL	34567 901234
PRTPARM	34567 901234
LABEL	34567 901234
END	34567 901234

3.7.3.5 File Name Restart Table

DMAP	Bit Position				DMAP	Bit Position			
Inst.	94	100	110	120	Inst.	94	100	110	120
BEGIN					LABEL		1		
FILE					PARAM		2		
FILE					GP4		2		
GP1	4				SAVE		2		
SAVE	4				PARAM		2		
CHKPNT	4				PURGE		2 5 789	1 345	
GP2	5				EQUIV				
CHKPNT	5				CHKPNT				
PLTSET				1	SSG1		3		
SAVE				1	CHKPNT		3		
PRTMSG				1	EQUIV		3		
SETVAL				1	CHKPNT		3		
SAVE				1	COND		4		
COND					GPSP		4		
PLOT					OFP		4		
SAVE					SAVE		4		
PRTMSG					LABEL		4		
LABEL					PARAM				
CHKPNT				1	COND		56		
GP3	6				MCE1		5		
SAVE	6				CHKPNT		5		
PARAM	6 9				JUMP				
PURGE	6				LABEL				
CHKPNT	6				EQUIV		6		
TA1,	7				CHKPNT		6		
SAVE	7				COND		6		
PARAM	7				MCE2		6		
COND	7				CHKPNT		6		
PURGE	78				LABEL		56		
CHKPNT	7				EQUIV		7		
COND	89				CHKPNT		7		
SMA1	8				COND		7		
CHKPNT	8				SCE1		7		
COND	9				CHKPNT		7		
SMA2	9				LABEL		7		
SAVE	9				EQUIV		8		
CHKPNT	9				CHKPNT		8		
COND					COND		8		
COND					SMP1		8		
GPWG					CHKPNT		8		
OFP					LABEL		8		
SAVE					EQUIV		9		
LABEL	89				CHKPNT		9		
PLA1		0			COND		9		
SAVE		0			RBMG1		9		
COND		0			CHKPNT		9		
PURGE		0			LABEL		9		
CHKPNT		0			DECOMP			0	
PARAM		0			SAVE			0	
PARAM		0			COND			0	
EQUIV		1			CHKPNT			0	
CHKPNT		1			COND			1	
COND		1			RBMG3			1	
SMA3		1			CHKPNT			1	
CHKPNT		1			LABEL			1	
SMA3		1			ADD			2	
CHKPNT		1			CHKPNT			2	

DMAP Inst.	Bit Position (94 100 110 120)
COND	3
SSG2	3
CHKPNT	3
LABEL	3
SSG3	4
SAVE	4
CHKPNT	4
COND	
MATGPR	
MATGPR	
LABEL	
SDR1	5
CHKPNT	5
PLA2	6
SAVE	
CHKPNT	
EQUIV	7
COND	7
PLA3	7
CHKPNT	7
OFP	
SAVE	
LABEL	7
PARAM	8
COND	8
PLA4	8
SAVE	8
CHKPNT	8
EQUIV	9
CHKPNT	9
COND	9
ADD	9
CHKPNT	9
LABEL	9
EQUIV	
CHKPNT	
EQUIV	
CHKPNT	
COND	
PLA2	
PLA2	
LABEL	
REPT	
JUMP	
LABEL	
PRTPARM	
LABEL	
SDR2	0
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
JUMP	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
END	

3.7.4 Case Control Deck and Parameters for Piecewise Linear Analysis

The following items relate to subcase definition and data selection for Piecewise Linear Analysis:

1. The Case Control Deck must contain one and only one subcase.

2. A static loading condition must be defined with a LØAD selection.

3. An SPC set must be selected unless all constraints are specified on GRID cards.

4. PLCØEFFICIENT must appear either to select a PLFACT set from the Bulk Data Deck or to explicitly select the default value of unity.

The following output may be requested for Piecewise Linear Analysis:

1. Accumulated sums of displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for each load increment.

2. Stresses in selected elements. If an element is composed of a nonlinear material the accumulated stress will be output for each load increment. Stresses in linear elements are only calculated for the total load.

3. Undeformed plot of the structural model and deformed plots for each load increment.

The following parameters are used in Piecewise Linear Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.8 DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.1 DMAP Sequence for Direct Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1 BEGIN    NO.7 DIRECT COMPLEX EIGENVALUE ANALYSIS - SERIES M1 $

  2 FILE     KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

  3 GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
             123/V,N,NOGPDT $

  4 SAVE     LUSET,NOGPDT $

  5 PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,EST,ECT,PLTSETX,PLTPAR,GPSETS,
             ELSETS/NOGPDT $

  6 CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,EST,
             ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

  7 COND     LBL5,NOGPDT $

  8 GP2      GEOM2,EQEXIN/ECT $

  9 CHKPNT   ECT $

 10 PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
             JUMPPLOT $

 11 SAVE     NSIL,JUMPPLOT $

 12 PRTMSG   PLTSETX// $

 13 SETVAL   //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 14 SAVE     PLTFLG,PFILE $

 15 COND     P1,JUMPPLOT $

 16 PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
             NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 17 SAVE     PFILE $

 18 PRTMSG   PLOTX1// $

 19 LABEL    P1 $

 20 CHKPNT   PLTPAR,GPSETS,ELSETS $

 21 GP3      GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 22 CHKPNT   GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

 23  TA1,     ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
              123/ V,N,NOSIMP=-1/C,N,0/V,N,NOGENL=-1/V,N,GENEL $

 24  SAVE     NOSIMP,NOGENL,GENEL $

 25  PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
              KGGX/NOSIMP / OGPST/GENEL $

 26  CHKPNT   EST,ECPT,GPCT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,
              K4AA,MNN,MFF,MAA,BNN,BFF,BAA $

 27  COND     LBL1,NOSIMP $

 28  SMA1     CSTM,MPT,ECPT,GPCT,DIT/KGGX,K4GG,GPST/V,N,NOGENL/V,N,NOK4GG $

 29  SAVE     NOK4GG $

 30  PURGE    K4NN,K4FF,K4AA/NOK4GG $

 31  CHKPNT   KGGX,GPST,K4GG,K4NN,K4FF,K4AA $

 32  SMA2     CSTM,MPT,ECPT,GPCT,DIT/MGG,BGG/V,Y,WTMASS=1.0/V,N,NOMGG/   V,N,
              NOBGG=-1/V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/  V,Y,
              CPQUAD2/V,Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/ V,Y,
              CPTRPLT/V,Y,CPTRBSC $

 33  SAVE     NOMGG,NOBGG $

 34  PURGE    BNN,BFF,BAA/NOBGG/MNN,MFF,MAA/NOMGG $

 35  CHKPNT   MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 36  COND     LBL1,GRDPNT $

 37  COND     ERROR3,NOMGG $

 38  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 39  OFP      OGPWG,,,,,//V,N,CARDNO $

 40  SAVE     CARDNO $

 41  LABEL    LBL1 $

 42  EQUIV    KGGX,KGG/NOGENL $

 43  CHKPNT   KGG $

 44  COND     LBL11,NOGENL $

 45  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 46  CHKPNT   KGG $
```

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RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 47  LABEL    LBL11 $

 48  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 49  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1/ V,
              N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
              V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

 50  SAVE     MPCF1,MPCF2,SINGLE,OMIT,NSKIP,NOSET,REACT,REPEAT,NOL,NOA $

 51  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $

 52  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

 53  CHKPNT   GM,GMD,RG,GO,GOD,KFS,QPC,USET,KNN,MNN,BNN,K4NN $

 54  COND     LBL4,GENEL $

 55  COND     LBL4,NOSIMP $

 56  GPSP     GPL,GPST,USET,SIL/OGPST $

 57  OFP      OGPST,,,,,//V,N,CARDNO $

 58  SAVE     CARDNO $

 59  LABEL    LBL4 $

 60  COND     LBL2,MPCF2 $

 61  MCE1     USET,RG/GM $

 62  CHKPNT   GM $

 63  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

 64  CHKPNT   KNN,MNN,BNN,K4NN $

 65  LABEL    LBL2 $

 66  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

 67  CHKPNT   KFF,MFF,BFF,K4FF $

 68  COND     LBL3,SINGLE $

 69  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $

 70  CHKPNT   KFS,KFF,MFF,BFF,K4FF $

 71  LABEL    LBL3 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 72  EQUIV     KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT $

 73  CHKPNT    KAA,MAA,BAA,K4AA $

 74  COND      LBL5,OMIT $

 75  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,LOO,,,,, $

 76  CHKPNT    GO,KAA $

 77  COND      LBLM,NOMGG $

 78  SMP2      USET,GO,MFF/MAA $

 79  CHKPNT    MAA $

 80  LABEL     LBLM $

 81  COND      LBLB,NOBGG $

 82  SMP2      USET,GO,BFF/BAA $

 83  CHKPNT    BAA $

 84  LABEL     LBLB $

 85  COND      LBL5,NOK4GG $

 86  SMP2      USET,GO,K4FF/K4AA $

 87  CHKPNT    K4AA $

 88  LABEL     LBL5 $

 89  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V,
               N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/
               V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 90  SAVE      LUSETD,NOUE $

 91  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $

 92  CHKPNT    USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $

 93  PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

 94  PARAM     //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $

 95  BMG       MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
               MFACT $

 96  SAVE      MFACT,NOKBFL,NOABFL $
```

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RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  97  PARAM     //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

  98  PURGE     KBFL/NOKBFL/ ABFL/NOABFL $

  99  COND      LBLFL3,NOFL $

 100  MTRXIN,   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
                N,0 $

 101  SAVE      NOABFL,NOKBFL $

 102  LABEL     LBLFL3 $

 103  CHKPNT    ABFL,KBFL $

 104  JUMP      LBL13 $
                                                          Top of DMAP Loop
 105  LABEL     LBL13 $

 106  PURGE     PHID,CLAMA,OPHID,OQPC1,OCPHIP,OESC1,OEFC1,CPHIP,QPC,  K2PP,
                M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

 107  CASE      CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

 108  SAVE      REPEATE,NOLOOP $

 109  CHKPNT    CASEXX $

 110  MTRXIN    CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
                NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

 111  SAVE      NOK2DPP,NOM2DPP,NOB2PP $

 112  PARAM     //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

 113  PARAM     //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

 114  EQUIV     K2DPP,K2XPP/NOKBFL/ M2DPP,M2PP/NOABFL $

 115  COND      LBLFL1,NOKBFL $

 116  EQUIV     KBFL,K2XPP/NOK2DPP $

 117  COND      LBLFL1,NOK2DPP $

 118  ADD       KBFL,K2DPP/K2XPP $

 119  LABEL     LBLFL1 $

 120  EQUIV     K2XPP,K2PP/NOABFL $

 121  COND      LBLFL2,NOABFL $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

122  ADD      ABFL,K2XPP/K2PP/C,N,(-1.0,0.0) $

123  TRNSP    ABFL/ABFLT $

124  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

125  LABEL    LBLFL2 $

126  PARAM    //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

127  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

128  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

129  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

130  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
              BDD/BDEBA $

131  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

132  COND     LBL18,NOGPDT $

133  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,CMPLEV/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/C,
              N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/    V,N,MPCF1/V,
              N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,N,
              -1 $

134  LABEL    LBL18 $

135  EQUIV    B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

136  CHKPNT   KDD,BDD,MDD,GOD,GMD $

137  COND     ERROR1,NOEED $

138  CEAD     KDD,BDD,MDD,EED,CASEXX/PHID,CLAMA,OCEIGS/V,N,EIGVS $

139  SAVE     EIGVS $

140  CHKPNT   PHID,CLAMA,OCEIGS $

141  OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $

142  SAVE     CARDNO $

143  COND     LBL16,EIGVS $

144  VDR      CASEXX,EQDYN,USETD,PHID,CLAMA,,/OPHID,/C,N,CEIGN/C,N,DIRECT/C,
              N,0/V,N,NOD/V,N,NOP/C,N,0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 7

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

145  SAVE     NOD,NOP $

146  COND     LBL15,NOD $

147  OFP      OPHID,,,,,//V,N,CARDNO $

148  SAVE     CARDNO $

149  LABEL    LBL15 $

150  COND     LBL16,NOP $

151  EQUIV    PHID,CPHIP/NCA $

152  COND     LBL17,NOA $

153  SDR1     USETD,, PHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS $

154  LABEL    LBL17 $

155  CHKPNT   CPHIP,QPC $

156  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,/,OQPC1,
              OCPHIP,OESC1,OEFC1,/C,N,CEIG $

157  OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $

158  SAVE     CARDNO $

159  LABEL    LBL16 $

160  COND     FINIS,REPEATE $

161  REPT     LBL13,100 $

162  JUMP     ERROR2 $
-----------------------------------------------------  Bottom of DMAP Loop
163  JUMP     FINIS $

164  LABEL    ERROR2 $

165  PRTPARM  //C,N,-2/C,N,DIRCEAD $

166  LABEL    ERROR1 $

167  PRTPARM  //C,N,-1/C,N,DIRCEAD $

168  LABEL    ERROR3 $

169  PRTPARM  //C,N,-3/C,N,DIRCEAD $

170  LABEL    FINIS $

171  END      $
```

3.8.2 Description of DMAP Operations for Direct Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 88 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plot request.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

27. Go to DMAP No. 41 if there are no structural elements.

28. SMA1 generates stiffness matrix $[K^x_{gg}]$, structural damping matrix $[K^4_{gg}]$ and Grid Point Singularity Table.

32. SMA2 generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.

36. Go to DMAP No. 41 if no weight and balance request.

37. Go to DMAP No. 168 and print error message if no mass matrix exists.

38. GPWG generates weight and balance information.

39. ØFP formats the weight and balance information and places it on the system output file for printing.

42. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

44. Go to DMAP No. 47 if no general elements.

45. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

49. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

52. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

54. Go to DMAP No. 59 if general elements present.

55. Go to DMAP No. 59 if no structural elements.

56. GPSP determines if possible grid point singularities remain.

57. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

60. Go to DMAP No. 65 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

61. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

63. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right], \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right],$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G_m^T][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G_m^T][K^4_{mm}][G_m].$$

66. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

68. Go to DMAP No. 71 if no single-point constraints.

69. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \qquad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right],$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right]$$

72. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

74. Go to DMAP No. 88 if no omitted coordinates.

75. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1} [K_{oa}]$
and performs matrix reduction

$$[K^1{}_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

77. Go to DMAP No. 80 if no mass matrix.

78. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{ao} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

81. Go to DMAP No. 84 if no viscous damping matrix.

82. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

85. Go to DMAP No. 88 if no structural damping matrix.

86. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

89. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

91. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

95. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

99. Go to DMAP No. 102 if no fluid structure interface is defined.

100. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

104. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

105. Beginning of loop for additional sets of direct input matrices.

107. CASE extracts user requests from CASECC for current loop.

110. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B_{pp}]$.

114. Equivalence $[K^{2d}_{pp}]$ to $[K^{2x}_{pp}]$ if no $[K_{b,f\ell}]$ and $[M^{2d}_{pp}]$ to $[M^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

115. Go to DMAP No. 112 if no $[K_{b,f\ell}]$.

116. Equivalence $[K_{b,f\ell}]$ to $[K^{2x}_{pp}]$ if no $[K^{2d}_{pp}]$.

117. Go to DMAP No. 112 if no $[K^{2d}_{pp}]$.

118. ADD assembles matrix $[K^{2x}_{pp}] = [K_{b,f\ell}] + [K^{2d}_{pp}]$.

120. Equivalence $[K^{2x}_{pp}]$ to $[K^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

121. Go to DMAP No. 125 if no $[A_{b,f\ell}]$.

122. Add subtracts $[A_{b,f\ell}]$ from $[K^{2x}_{pp}]$ to obtain $[K^{2}_{pp}]$.

123. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

124. ADD assembles input matrix $[M^{2}_{pp}] = \text{MFACT}\,[A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

130. Equivalence $[M^{2}_{pp}]$ to $[M^{2}_{dd}]$, $[B^{2}_{pp}]$ to $[B^{2}_{dd}]$ and $[K^{2}_{pp}]$ to $[K^{2}_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

132. Go to DMAP No. 134 if only extra points defined.

133. GKAD assembles stiffness, mass, and damping matrices for use in Direct Complex Eigenvalue Analysis

$$[K_{dd}] = (1 + ig)[K^{1}_{dd}] + [K^{2}_{dd}] + i[K^{4}_{dd}],$$

$$[M_{dd}] = [M^{1}_{dd}] + [M^{2}_{dd}] \text{ and}$$

$$[B_{dd}] = [B^{1}_{dd}] + [B^{2}_{dd}].$$

Direct input matrices may be complex.

135. Equivalence $[K^{2}_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^{2}_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^{2}_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

137. Go to DMAP No. 166 and print error message if no Eigenvalue Extraction Data.

138. CEAD extracts complex eigenvalues from the equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = 0$$

and normalizes eigenvectors according to one of the following user requests:

(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

141. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

143. Go to DMAP No. 159 if no eigenvalues found.

144. VDR prepares eigenvectors for output, using only the independent degrees of freedom.

146. Go to DMAP No. 149 if no output request for the independent degrees of freedom.

147. ØFP formats the eigenvectors for independent degrees of freedom and places them on the system output file for printing.

150. Go to DMAP No. 159 if no output request involving dependent degrees of freedom or forces and stresses.

151. Equivalence $\{\phi_d\}$ to $\{\phi_p\}$ if no constraints applied.

152. Go to DMAP No. 154 if no constraints applied.

153. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \ , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi_f + \phi_e\} \ ,$$

$$\left\{\begin{array}{c}\phi_f + \phi_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + \phi_e\} \ , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \ ,$$

$$\left\{\begin{array}{c}\phi_n + \phi_e \\ \hline d_m\end{array}\right\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}^T]\{\phi_f\} \ .$$

156. SDR2 calculates element forces and stresses (OEFC1, OESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1).

157. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

160. Go to DMAP No. 170 if no additional sets of direct input matrices need to be processed.

161. Go to DMAP No. 105 if additional sets of direct input matrices need to be processed.

162. Go to DMAP No. 164 and print error message if more than 100 loops.

163. Go to DMAP No. 170 and make normal exit.

165. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

167. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

169. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.8.3 Restart Tables for Direct Complex Eigenvalue Analysis

3.8.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
AXIC	1
AXIF	1
CDAMP1	1
CDAMP2	1
CDAMP3	1
CDAMP4	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CMASS1	1
CMASS2	1
CMASS3	1
CMASS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
FREEPT	1
GRDSET	1
GRID	1
GRIDB	1
POINTAX	1
PREPT	1
RINGAX	1
RINGFL	1
SECTAX	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CCONEAX	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CFLUID2	2
CFLUID3	2
CFLUID4	2
CHEXA1	2
CHEXA2	2
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQDPLT	2
CQUAD1	2
CQUAD2	2
CROD	2
CSHEAR	2
CTETRA	2
CTORDRG	2
CTRAPRG	2
CTRBSC	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTRPLT	2
CTUBE	2
CTWIST	2
CWEDGE	2
PBAR	3
PCONEAX	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQDPLT	3
PQUAD1	3
PQUAD2	3
PROD	3
PSHEAR	3
PTORDRG	3
PTRBSC	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTRPLT	3
PTUBE	3
PTWIST	3
GENEL	4
CONM1	5
CONM2	5
FSLIST	5
PELAS	6
PMASS	7
MAT1	8
MAT2	8
MAT3	8
MATT1	8
MATT2	8
MATT3	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8
TEMPMX$	8
AXISYM$	9
MPC	9
MPCADD	9
MPCAX	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPCAX	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
OMITAX	11
PARAM	12
SUPAX	12
SUPORT	12
TEMP	13
TEMPAX	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
WTMASS	14
GRDPNT	15
PLOTEL	16
PLOT$	18
POUT$	19
AOUT$	21
LOOP$	22
LOOP1$	23
COUPMASS	24
CPBAR	24
CPQDPLT	24
CPQUAD1	24
CPQUAD2	24
CPROD	24
CPTRBSC	24
CPTRIA1	24
CPTRIA2	24
CPTRPLT	24
CPTUBE	24
NOLOOP$	25
BDYLIST	52

Card Name	Bit Pos.
FLSYM	52
G	56
EPOINT	57
SEQEP	57
TF	57
CVISC	58
PDAMP	59
PVISC	59
DMIAX	60
DMIG	60
B2PP$	60
K2PP$	60
M2PP$	60
TF$	60
EIGC	61
EIGP	61
CMETHOD$	62

3.8.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
K4GG	98
KGGX	98
BGG	99
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
BNN	104
K4NN	104
KNN	104
MNN	104
BFF	105
K4FF	105
KFF	105
KFS	105
MFF	105
GO	106
KAA	106
EED	107
EQDYN	107
GPLD	107
SILD	107
TFPOOL	107
USETD	107
CASEXX	108
B2PP	109
K2PP	109
M2PP	109
B2DD	110
BDD	110
GMD	110
GOD	110
K2DD	110
KDD	110
M2DD	110
MDD	110
CLAMA	111
OCEIGS	111
PHID	111
OPHID	112
CPHIP	113

File Name	Bit Pos.
QPC	113
OCPHIP	114
OEFC1	114
OESC1	114
OQPC1	114
BDPOOL	118
ABFL	119
KBFL	119
ELSETS	120
GPSETS	120
PLTPAR	120
PLTSETX	120
MAA	121
K4AA	123
BAA	122

3.8.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 89	1234			2 67890	12
FILE	1234567890	123456 89	1234			2 67890	12
GP1	1						
SAVE	1						
PURGE	1						
CHKPNT	1						
COND	1						
GP2	12 45	6				8	
CHKPNT	12 45	6				8	
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	1	3					
CHKPNT	1	3					
TA1,	1234567	3				89	
SAVE	1234567	3				89	
PURGE	1234567	3				89	
CHKPNT	1234567	3				89	
COND	123 5678	345					
SMA1	123 6 8						
SAVE	123 6 8						
PURGE	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4			89	
SAVE	123 5 78	4	4			89	
PURGE	123 5 78	4	4			89	
CHKPNT	123 5 78	4	4			89	
COND	123 5 78	45	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 7	45	4				
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	1					
GP4	1 90	1					
SAVE	1 90	1					
PURGE	1 90	1					
EQUIV	123456789	4	4				
CHKPNT	1234567890	1 4	4				
COND	123 6 8 0						
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						

Bit Position

DMAP Inst.	1 10	20	30	40	50	60	
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						
MCE2	123456789	4	4			89	
CHKPNT	123456789	4	4			89	
LABEL	123456789	4	4			89	
EQUIV	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
COND	1234567890	4	4			89	
SCE1	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
LABEL	1234567890	4	4			89	
EQUIV	1234567890	1 4	4			89	
CHKPNT	1234567890	1 4	4			89	
COND	1234567890	1 4	4			89	
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
COND	1234567890	1 4	4				
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
COND	1234 6 890	1				89	
SMP2	1234 6 890	1				89	
CHKPNT	1234 6 890	1				89	
LABEL	1234 6 890	1				89	
COND	1234 6 890	1					
SMP2	1234 6 890	1					
CHKPNT	1234 6 890	1					
LABEL	1234567890	1 4	4			89	
DPD	1 90	1				7	1
SAVE	1 90	1				7	1
EQUIV	1234567890	1 4	234			2 67890	
CHKPNT	1 90	1				7	1
PARAM			23				
PARAM	1234567890	1234 6	23			2 67890	12
BMG	1					2	
SAVE	1					2	
PARAM	1		23			2 7 0	
PURGE	1					2	
COND	1					2	
MTRXIN	1					2	
SAVE	1					2	
LABEL	1					2	
CHKPNT	1					2	
JUMP			23				
$SS	1 3						
LABEL	1234567890	123456 89	123			2 67890	12
$SS	1 3						
PURGE			23				
CASE	1234567890	123456 9	123 5			2 67890	12
SAVE	1234567890	123456 9	123 5			2 67890	12
CHKPNT	1234567890	123456 9	123 5			2 67890	12
MTRXIN	1		23			2 7 0	
SAVE	1		23			2 7 0	
PARAM	1		23			2 7 0	

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
PARAM	1		23			2 7 0	
EQUIV	1		23			2 7 0	
COND	1		23			2 7 0	
EQUIV	1		23			2 7 0	
COND	1		23			2 7 0	
ADD	1		23			2 7 0	
LABEL	1		23			2 7 0	
EQUIV	1		23			2 7 0	
COND	1		23			2 7 0	
ADD	1		23			2 7 0	
TRNSP	1		23			2 7 0	
ADD	1		23			2 7 0	
LABEL	1		23			2 7 0	
PARAM	1		23			2 7 0	
PARAM	1		23			2 7 0	
PARAM	1		23			2 7 0	
PURGE	1234567890	1 4	234			2 67890	
EQUIV	1234567890	1 4	234			2 67890	
CHKPNT	1234567890	1 4	234			2 67890	
COND	1234567890	1 4	234			2 67890	
GKAD	1234567890	1 4	234			2 67890	
LABEL	1234567890	1 4	234			2 67890	
EQUIV	1234567890	1 4	234			2 67890	
CHKPNT	1234567890	1 4	234			2 67890	
COND	1234567890	1 4	234			2 67890	
CEAD	1234567890	1 4	234			2 67890	12
SAVE	1234567890	1 4	234			2 67890	12
CHKPNT	1234567890	1 4	234			2 67890	12
OFP	1234567890	1 4	234			2 67890	12
SAVE	1234567890	1 4	234			2 67890	12
COND		9	1				
VDR		9	1				
SAVE		9	1				
COND			1				
OFP			1				
SAVE			1				
LABEL			1				
COND	1234567890	1 4	234			2 67890	12
EQUIV	1234567890	1 4	234			2 67890	12
COND	1234567890	1 4	234			2 67890	12
SDR1	1234567890	1 4	234			2 67890	12
LABEL	1234567890	1 4	234			2 67890	12
CHKPNT	1234567890	1 4	234			2 67890	12
SDR2		9					
OFP		9					
SAVE		9					
LABEL	1234567890	1	234				
COND			23			2 67890	12
$SS	1 3						
REPT			23			2 67890	12
$SS	1 3						
JUMP			23			2	
$SS	1 3						
JUMP	1234567890	123456 89	1234			67890	12
LABEL			23				
$SS	1 3						
PRTPARM			23			2 67890	12

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
$SS	1 3						
LABEL	1234567890	123456 89	1234			2 67890	12
PRTPARM	1234567890	123456 89	1234			2 67890	12
LABEL	1234567890	123456 89	1234			2 67890	12
PRTPARM	1234567890	123456 89	1234			2 67890	12
LABEL	1234567890	123456 89	1234			2 67890	12
END	1234567890	123456 89	1234			2 67890	12

3.8.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 — 70 — 80
BEGIN	345678 01234
FILE	345678 01234
GP1	
SAVE	
PURGE	
CHKPNT	
COND	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
PURGE	
CHKPNT	
COND	
SMA1	
SAVE	
PURGE	
CHKPNT	
SMA2	3 678
SAVE	3 678
PURGE	3 678
CHKPNT	3 678
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PURGE	
EQUIV	
CHKPNT	
COND	
COND	
GPSP	
OFP	

DMAP Inst.	Bit Position 63 — 70 — 80
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
DPD	
SAVE	
EQUIV	
CHKPNT	
PARAM	
PARAM	345678 01234
BMG	
SAVE	
PARAM	
PURGE	
COND	
MTRXIN	
SAVE	
LABEL	
CHKPNT	
JUMP	345678 01234
LABEL	345678 01234
PURGE	
CASE	345678 01234
SAVE	345678 01234
CHKPNT	345678 01234
MTRXIN	
SAVE	
PARAM	
PARAM	
EQUIV	

DMAP Inst.	Bit Position 63	70	80
COND			
EQUIV			
COND			
ADD			
LABEL			
EQUIV			
COND			
ADD			
TRNSP			
ADD			
LABEL			
PARAM			
PARAM			
PARAM			
PURGE			
EQUIV			
CHKPNT			
COND		1	
GKAD		1	
LABEL		1	
EQUIV			
CHKPNT			
COND	345678 01234		
CEAD			
SAVE			
CHKPNT			
OFP			
SAVE			
COND			
VDR			
SAVE			
COND			
OFP			
SAVE			
LABEL			
COND	345678 01234		
EQUIV	345678 01234		
COND	345678 01234		
SDR1	345678 01234		
LABEL			
CHKPNT			
SDR2			
OFP			
SAVE			
LABEL			
COND	345678 01234		
REPT	345678 01234		
JUMP	345678 01234		
JUMP	345678 01234		
LABEL	345678 01234		
PRTPARM	345678 01234		
LABEL	345678 01234		
PRTPARM	345678 01234		
LABEL	345678 01234		
PRTPARM	345678 01234		
LABEL	345678 01234		
END	345678 01234		

3.8.3.5 File Name Restart Table

DMAP Inst.	94	100	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
PURGE				
CHKPNT				
COND				
GP2	5			
CHKPNT	5			
PLTSET				0
SAVE				0
PRTMSG				0
SETVAL				0
SAVE				0
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				0
GP3	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
PURGE	789	2 456		123
CHKPNT	7			
COND	8			
SMA1	8			
SAVE	8			
PURGE	8	456		
CHKPNT	8			
SMA2	9			
SAVE	9			
PURGE	9			
CHKPNT	9			
COND				
COND				
GPWG				
OFP				
SAVE				
LABEL	8			
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
PURGE		1 3 56	0 3	
EQUIV		4		
CHKPNT				
COND		2		
COND		2		
GPSP		2		
OFP		2		

DMAP Inst.	94	100	110	120
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		123
CHKPNT		6		123
COND		6		123
SMP1		6		
CHKPNT		6		
COND				1
SMP2				1
CHKPNT				1
LABEL				1
COND				2
SMP2				2
CHKPNT				2
LABEL				2
COND				3
SMP2				3
CHKPNT				3
LABEL		6		123
DPD		7		
SAVE		7		
EQUIV			0	
CHKPNT		7		
PARAM				
PARAM		8		
BMG			8	
SAVE			8	
PARAM		9	9	
PURGE			8	
COND			9	
MTRXIN			9	
SAVE			9	
LABEL			9	
CHKPNT			9	
JUMP		8		
LABEL		8		
PURGE				
CASE		8		
SAVE		8		
CHKPNT		8		
MTRXIN		9		
SAVE		9		
PARAM		9		
PARAM		9		
EQUIV		9		

DMAP Inst.	Bit Position 94 100 110 120
COND	9
EQUIV	9
COND	9
ADD	9
LABEL	9
EQUIV	9
COND	9
ADD	9
TRNSP	9
ADD	9
LABEL	9
PARAM	9
PARAM	9
PARAM	9
PURGE	0
EQUIV	0
CHKPNT	0
COND	0
GKAD	0
LABEL	0
EQUIV	1
CHKPNT	1
COND	1
CEAD	1
SAVE	1
CHKPNT	1
OFP	1
SAVE	1
COND	2
VDR	2
SAVE	2
COND	2
OFP	2
SAVE	2
LABEL	2
COND	3
EQUIV	3
COND	3
SDR1	3
LABEL	3
CHKPNT	3
SDR2	4
OFP	
SAVE	
LABEL	23
COND	
REPT	
JUMP	
JUMP	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
END	

3.8.4 Automatic Output for Direct Complex Eigenvalue Analysis

Each complex eigenvalue is identified with a root number determined by sorting the complex eigenvalues according to the magnitude of the imaginary part, with positive values considered as a group ahead of all negative values. The following summary of the complex eigenvalues extracted is automatically printed for each set of direct input matrices:

1. Root Number
2. Extraction Order
3. Real and Imaginary Parts of the Eigenvalue
4. The coefficients f_j (frequency) and g_j (damping coefficient) in the following representation of the eigenvalue

$$P_j = 2\pi f_j (i - \frac{1}{2} g_j)$$

The following summary of the eigenvalue analysis performed using the Determinant method is automatically printed for each set of direct input matrices:

1. Number of eigenvalues extracted
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Number of predictions outside region.
8. Reason for termination:
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the regions specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
9. Swept determinant functions for each starting point.

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed for each region specified:

1. Number of eigenvalues extracted.

2. Number of starting points used.

3. Number of starting point moves.

4. Number of triangular decompositions.

5. Number of vector iterations.

6. Reason for termination.

    (1) Two consecutive singularities encountered while performing triangular decomposition.

    (2) Four starting point moves while tracking a single root.

    (3) All eigenvalues found in the region specified.

    (4) Three times the number of roots estimated in the region have been extracted.

    (5) All eigenvalues that exist in the problem have been found.

    (6) The number of roots desired have been found.

    (7) One or more eigenvalues have been found outside the region specified.

    (8) Insufficient time to find another root.

    (9) Unable to converge.

3.8.5 Case Control Deck and Parameters for Direct Complex Eigenvalue Analysis

The following items relate to subcase definition and data selections for Direct Complex Eigenvalue Analysis.

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP).

2. Multiple subcases for each set of direct input matrices are used only to control output requests. A single subcase for each set of direct input matrices is sufficient if the same output is desired for all modes. If consecutive multiple subcases are present for a single set of direct input matrices, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck for each set of direct input matrices.

4. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and either CMETHØD must be changed to select an EIGC card that reflects any complex eigenvalues found in the previous execution or EIGP cards must be used to insert poles for previously found eigenvalues. Otherwise, the previously found eigenvalues will be extracted again.

5. Constraints must be defined above the subcase level.

The following printed output, sorted by complex eigenvalue root number (SØRT1), may be requested for any complex eigenvalue extracted, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements.

In addition an undeformed plot of the structural model may be requested.

The following parameters are used in Direct Complex Eigenvalue Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. <u>CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC</u> - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.9 DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.1 DMAP Sequence for Direct Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

    N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.8 DIRECT FREQUENCY RESPONSE ANALYSIS - SERIES M1 $

  2  FILE     KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
              123/V,N,NOGPDT $

  4  SAVE     LUSET,NOGPDT $

  5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,
              GPSETS,ELSETS/NOGPDT $

  6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
              KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

  7  COND     LBL5,NOGPDT $

  8  GP2      GEOM2,EQEXIN/ECT $

  9  CHKPNT   ECT $

 10  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT $

 11  SAVE     NSIL,JUMPPLOT $

 12  PRTMSG   PLTSETX// $

 13  SETVAL   //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 14  SAVE     PLTFLG,PFILE $

 15  COND     P1,JUMPPLOT $

 16  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 17  SAVE     PFILE $

 18  PRTMSG   PLOTX1//$

 19  LABEL    P1 $

 20  CHKPNT   PLTPAR,GPSETS,ELSETS $

 21  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 22  CHKPNT   GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 23  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP=-1/C,N,0/V,N,NOGENL=-1/V,N,GENEL $

 24  SAVE      NOSIMP,NOGENL,GENEL $

 25  PURGE     K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
               KGGX/NOSIMP/OGPST/GENEL $

 26  CHKPNT    EST,ECPT,GPCT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,
               K4AA,MNN,MFF,MAA,BNN,BFF,BAA $

 27  COND      LBL1,NOSIMP $

 28  SMA1      CSTM,MPT,ECPT,GPCT,DIT/KGGX,K4GG,GPST/V,N,NOGENL/V,N,NOK4GG $

 29  SAVE      NOK4GG $

 30  PURGE     K4NN,K4FF,K4AA/NOK4GG $

 31  CHKPNT    KGGX,GPST,K4GG,K4NN,K4FF,K4AA $

 32  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,BGG/V,Y,WTMASS=1.0/V,N,NOMGG/   V,N,
               NOBGG=-1/V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/  V,Y,
               CPQUAD2/V,Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/ V,Y,
               CPTRPLT/V,Y,CPTRBSC $

 33  SAVE      NOMGG,NOBGG $

 34  PURGE     BNN,BFF,BAA/NOBGG/MNN,MFF,MAA/NOMGG $

 35  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 36  COND      LBL1,GRDPNT $

 37  COND      ERROR4,NOMGG $

 38  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 39  OFP       OGPWG,,,,,//V,N,CARDNO $

 40  SAVE      CARDNO $

 41  LABEL     LBL1 $

 42  EQUIV     KGGX,KGG/NOGENL $

 43  CHKPNT    KGG $

 44  COND      LBL11,NOGENL $

 45  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 46  CHKPNT    KGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 47  LABEL     LBL11 $

 48  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 49  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1=-1/
               V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/V,N,REACT=-1/V,N,NSKIP/
               V,N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

 50  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $

 51  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF,QPC/SINGLE $

 52  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

 53  CHKPNT    GM,GMD,RG,GO,GOD,KFS,PSF,QPC,USET,KNN,MNN,BNN,K4NN $

 54  COND      LBL4,GENEL $

 55  COND      LBL4,NOSIMP $

 56  GPSP      GPL,GPST,USET,SIL/OGPST $

 57  OFP       OGPST,,,,,//V,N,CARDNO $

 58  SAVE      CARDNO $

 59  LABEL     LBL4 $

 60  COND      LBL2,MPCF1 $

 61  MCE1      USET,RG/GM $

 62  CHKPNT    GM $

 63  MCE2      USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

 64  CHKPNT    KNN,MNN,BNN,K4NN $

 65  LABEL     LBL2 $

 66  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

 67  CHKPNT    KFF,MFF,BFF,K4FF $

 68  COND      LBL3,SINGLE $

 69  SCE1      USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $

 70  CHKPNT    KFS,KFF,MFF,BFF,K4FF $

 71  LABEL     LBL3 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
NO.

 72  EQUIV     KFF,KAA/OMIT/MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT $

 73  CHKPNT    KAA,MAA,BAA,K4AA $

 74  COND      LBL5,OMIT $

 75  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,UOO,.,.,. $

 76  CHKPNT    GO,KAA $

 77  COND      LBLM,NOMGG $

 78  SMP2      USET,GO,MFF/MAA $

 79  CHKPNT    MAA $

 80  LABEL     LBLM $

 81  COND      LBLB,NOBGG $

 82  SMP2      USET,GO,BFF/BAA $

 83  CHKPNT    BAA $

 84  LABEL     LBLB $

 85  COND      LBL5,NOK4GG $

 86  SMP2      USET,GO,K4FF/K4AA $

 87  CHKPNT    K4AA $

 88  LABEL     LBL5 $

 89  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,.,.,
               EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,
               NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 90  SAVE      LUSETD,NOUE,NODLT,NOFRL,NOPSDL $

 91  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $

 92  CHKPNT    USETD,EQDYN,TFPOOL,DLT,FRL,GOD,GMD,SILD,PSDL,GPLD $

 93  PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

 94  PARAM     //C,N,MPY/V,N,REPEATF/C,N,-1/C,N,1 $

 95  BMG       MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
               MFACT $

 96  SAVE      MFACT,NOKBFL,NOABFL $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 97  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

 98  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $

 99  COND     LBLFL3,NOFL $

100  MTRXIN,  ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $

101  SAVE     NOABFL,NOKBFL $

102  LABEL    LBLFL3 $

103  CHKPNT   ABFL,KBFL $

104  JUMP     LBL13 $
                                                        Top of DMAP Loop
105  LABEL    LBL13 $

106  PURGE    OUDVC1,OUDVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
              OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,   K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD/NEVER $

107  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

108  SAVE     REPEATF,NOLOOP $

109  CHKPNT   CASEXX $

110  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

111  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

112  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

113  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

114  EQUIV    K2DPP,K2XPP/NOKBFL/ M2DPP,M2PP/NOABFL $

115  COND     LBLFL1,NOKBFL $

116  EQUIV    KBFL,K2XPP/NOK2DPP $

117  COND     LBLFL1,NOK2DPP $

118  ADD      KBFL,K2DPP/K2XPP $

119  LABEL    LBLFL1 $

120  EQUIV    K2XPP,K2PP/NOABFL $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

121  COND      LBLFL2,NOABFL $

122  ADD       ABFL,K2XPP/K2PP/C,N,(-1.0,0.0) $

123  TRNSP     ABFL/ABFLT $

124  ADD       ABFLT,M2DPP/M2PP/V,N,MFACT $

125  LABEL     LBLFL2 $

126  PARAM     //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

127  PARAM     //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

128  PARAM     //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

129  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

130  EQUIV     M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
               BDD/BDEBA $

131  CHKPNT    K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

132  COND      LBL18,NOGPDT $

133  GKAD      USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
               GOD,K2DD,M2DD,B2DD/C,N,FREQRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
               C,N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/    V,N,MPCF1/
               V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,
               N,-1 $

134  LABEL     LBL18 $

135  EQUIV     B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

136  CHKPNT    KDD,BDD,MDD,GMD,GOD $

137  COND      ERROR1,NOFRL $

138  COND      ERROR2,NODLT $

139  FRRD      CASEXX,USETD,DLT,FRL,GMD,GOD,KDD,BDD,MDD,,DIT/UDVF,PSF,PDF,PPF/
               C,N,DISP/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/
               V,N,NONCUP/V,N,FRQSET/C,Y,DECOMOPT=1 $

140  EQUIV     PPF,PDF/NOSET $

141  CHKPNT    PSF,PPF,UDVF,PDF $

142  VDR       CASEXX,EQDYN,USETD,UDVF,PPF,XYCDB,/OUDVC1,/C,N,FREQRESP/C,N,
               DIRECT/V,N,NCSORT2/V,N,NOD/V,N,NOP/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

143  SAVE     NOD,NOP,NOSORT2 $

144  COND     LBL15,NOD $

145  COND     LBL15A,NOSORT2 $

146  CHKPNT   OUDVC1 $

147  SDR3     OUDVC1,,,,,/OUDVC2,,,,, $

148  OFP      OUDVC2,,,,,//V,N,CARDNO $

149  SAVE     CARDNO $

150  CHKPNT   OUDVC2 $

151  XYTRAN   XYCDB,OUDVC2,,,,/XYPLTFA/C,N,FREQ/C,N,DSET/V,N,PFILE/V,N,
              CARDNO $

152  SAVE     PFILE,CARDNO $

153  XYPLOT   XYPLTFA// $

154  JUMP     LBL15 $

155  LABEL    LBL15A $

156  OFP      OUDVC1,,,,,//V,N,CARDNO $

157  SAVE     CARDNO $

158  LABEL    LBL15 $

159  COND     LBL16,NOP $

160  EQUIV    UDVF,UPVC/NOA $

161  COND     LBL19,NOA $

162  SDR1     USETD,,UDVF,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

163  LABEL    LBL19 $

164  CHKPNT   UPVC,QPC $

165  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,QPC,UPVC,EST,XYCDB/OPPC1,
              OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQRESP/V,N,NOSORT2 $

166  SAVE     NOSORT2 $

167  COND     LBL17,NOSORT2 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

168  SDR3     OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
              OEFC2, $

169  CHKPNT   OPPC2,OQPC2,OUPVC2,OESC2,OEFC2 $

170  OFP      OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

171  SAVE     CARDNO $

172  XYTRAN   XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
              V,N,PFILE/V,N,CARDNO $

173  SAVE     PFILE,CARDNO $

174  XYPLOT   XYPLTF// $

175  COND     LBL16,NOPSDL $

176  RANDOM   XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
              V,N,NORD $

177  SAVE     NORD $

178  CHKPNT   PSDF,AUTO $

179  COND     LBL16,NORD $

180  XYTRAN   XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
              CARDNO $

181  SAVE     PFILE,CARDNO $

182  XYPLOT   XYPLTR// $

183  JUMP     LBL16 $

184  LABEL    LBL17 $

185  OFP      OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $

186  SAVE     CARDNO $

187  LABEL    LBL16 $

188  COND     FINIS,REPEATF $

189  REPT     LBL13,100 $
------------------------------------------------------------  Bottom of DMAP Loop
190  JUMP     ERROR3 $

191  JUMP     FINIS $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 8

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

192  LABEL     ERROR3 $

193  PRTPARM   //C,N,-3/C,N,DIRFRRD $

194  LABEL     ERROR2 $

195  PRTPARM   //C,N,-2/C,N,DIRFRRD $

196  LABEL     ERROR1 $

197  PRTPARM   //C,N,-1/C,N,DIRFRRD $

198  LABEL     ERROR4 $

199  PRTPARM   //C,N,-4/C,N,DIRFRRD $

200  LABEL     FINIS $

201  END       $
```

3.9.2 Description of DMAP Operations for Direct Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 88 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plot request.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

27. Go to DMAP No. 41 if there are no structural elements.

28. SMA1 generates stiffness matrix $[K^x_{gg}]$, structural damping matrix $[K^4_{gg}]$ and Grid Point Singularity Table.

32. SMA2 generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.

36. Go to DMAP No. 41 if no weight and balance request.

37. Go to DMAP No. 198 and print error message if no mass matrix exists.

38. GPWG generates weight and balance information.

39. ØFP formats weight and balance information and places it on the system output file for printing.

42. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

44. Go to DMAP No. 47 if no general elements.

45. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

49. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

52. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

54. Go to DMAP No. 59 if general elements present.

55. Go to DMAP No. 59 if no structural elements.

56. GPSP determines if possible grid point singularities remain.

57. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

60. Go to DMAP No. 65 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

61. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

63. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G^T_m][K_{mn}] + [K^T_{mn}][G_m] + [G^T_m][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G^T_m][M_{mn}] + [M^T_{mn}][G_m] + [G^T_m][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G^T_m][B_{mn}] + [B^T_{mn}][G_m] + [G^T_m][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G^T_m][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G^T_m][K^4_{mm}][G_m].$$

66. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

68. Go to DMAP No. 71 if no single-point constraints.

69. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

72. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

74. Go to DMAP No. 88 if no omitted coordinates.

75. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o].$$

77. Go to DMAP No. 80 if no mass matrix.

78. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

81. Go to DMAP No. 84 if no viscous damping matrix.

82. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

85. Go to DMAP No. 88 if no structural damping matrix.

86. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

89. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.

91. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

95. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

99. Go to DMAP No. 102 if no fluid structure interface is defined.

100. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

104. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

105. Beginning of loop for additional sets of direct input matrices.

107. CASE extracts user requests from CASECC for current loop.

110. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^{2}_{pp}]$.

114. Equivalence $[K^{2d}_{pp}]$ to $[K^{2x}_{pp}]$ if no $[K_{b,f\ell}]$ and $[M^{2d}_{pp}]$ to $[M^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

115. Go to DMAP No. 112 if no $[K_{b,f\ell}]$.

116. Equivalence $[K_{b,f\ell}]$ to $[K^{2x}_{pp}]$ if no $[K^{2d}_{pp}]$.

117. Go to DMAP No. 112 if no $[K^{2d}_{pp}]$.

118. ADD assembles matrix $[K^{2x}_{pp}] = [K_{b,f\ell}] + [K^{2d}_{pp}]$.

120. Equivalence $[K^{2x}_{pp}]$ to $[K^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

121. Go to DMAP No. 118 if no $[A_{b,f\ell}]$.

122. ADD subtracts $[A_{b,f\ell}]$ from $[K^{2x}_{pp}]$ to obtain $[K^{2}_{pp}]$.

123. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

124. ADD assembles input matrix $[M^{2}_{pp}] = \text{MFACT } [A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

130. Equivalence $[M^{2}_{pp}]$ to $[M^{2}_{dd}]$, $[B^{2}_{pp}]$ to $[B^{2}_{dd}]$ and $[K^{2}_{pp}]$ to $[K^{2}_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

132. Go to DMAP No. 134 if only extra points defined.

133. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response

$$[K_{dd}] = (1 + ig)[K^{1}_{dd}] + [K^{2}_{dd}] + i[K^{4}_{dd}],$$

$$[M_{dd}] = [M^{1}_{dd}] + [M^{2}_{dd}] \text{ and}$$

$$[B_{dd}] = [B^{1}_{dd}] + [B^{2}_{dd}].$$

Direct input matrices may be complex.

135. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

137. Go to DMAP No. 196 and print error message if no Frequency Response List.

138. Go to DMAP No. 194 and print error message if no Dynamics Load Table.

139. FRRD forms the dynamic load vectors $\{P_d\}$ and solves for the displacements using the following equation

$$[-M_{dd}\omega^2 + iB_{dd}\omega + K_{dd}]\{u_d\} = \{P_d\}.$$

140 Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

142. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.

144. Go to DMAP No. 158 if no output request for the independent degrees of freedom.

145. Go to DMAP No. 155 if no output request for independent displacements sorted by point number.

147. SDR3 sorts the independent displacements by point number.

148. ØFP formats the requested independent displacements sorted by point number and places them on the system output file for printing.

151. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.

153. XYPLØT prepares the requested X-Y plots of the independent displacements vs. frequency.

156. ØFP formats the requested independent displacements sorted by frequency and places them on the system output file for printing

159. Go to DMAP No. 187 if no output request involving dependent degrees of freedom or forces and stresses.

160. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

161. Go to DMAP No. 163 if no constraints applied.

162. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G^d_o]\{u_d\} \quad , \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G^d_m]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K^T_{fs}]\{u_f\}$.

165. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPPC1, ØUPVC1, ØQPC1) - all sorted by frequency.

167. Go to DMAP No. 184 if no output requests sorted by point number or element number.

168. SDR3 prepares requested output sorted by point number or element number.

170. ØFP formats the requested output sorted by point number or element number and places it on the system output file for printing.

172. XYTRAN prepares the input for requested X-Y plots.

174. XYPLØT prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

175. Go to DMAP No. 187 if no Power Spectral Density List.

176. RANDØM calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.

179. Go to DMAP No. 187 if no RANDØM calculations requested.

180. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

182. XYPLØT prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

183. Go to DMAP No. 187 if no frequency response output requests sorted by frequency.

185. ØFP formats frequency response output requests sorted by frequency and places them on the system output file for printing.

188. Go to DMAP No. 200 if no additional sets of direct input matrices need to be processed.

189. Go to DMAP No. 105 if additional sets of direct input matrices need to be processed.

190. Go to DMAP No. 192 and print error message if more than 100 loops.

191. Go to DMAP No. 200 and make normal exit.

193. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

195. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

197. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

199. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.9.3 Restart Tables for Direct Frequency and Random Response

3.9.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
AXIC	1
AXIF	1
CDAMP1	1
CDAMP2	1
CDAMP3	1
CDAMP4	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CMASS1	1
CMASS2	1
CMASS3	1
CMASS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
FREEPT	1
GRDSET	1
GRID	1
GRIDB	1
POINTAX	1
PRESPT	1
RINGAX	1
RINGFL	1
SECTAX	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CCONEAX	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CFLUID2	2
CFLUID3	2
CFLUID4	2
CHEXA1	2
CHEXA2	2

Card Name	Bit Pos.
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQDPLT	2
CQUAD1	2
CQUAD2	2
CROD	2
CSHEAR	2
CTETRA	2
CTORDRG	2
CTRAPRG	2
CTRBSC	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTRPLT	2
CTUBE	2
CTWIST	2
CWEDGE	2
PBAR	3
PCONEAX	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQDPLT	3
PQUAD1	3
PQUAD2	3
PROD	3
PSHEAR	3
PTORDRG	3
PTRBSC	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTRPLT	3
PTUBE	3
PTWIST	3
GENEL	4
CONM1	5
CONM2	5
FSLIST	5
PELAS	6
PMASS	7
MAT1	8

Card Name	Bit Pos.
MAT2	8
MAT3	8
MATT1	8
MATT2	8
MATT3	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8
TEMPMX$	8
AXISYM$	9
MPC	9
MPCADD	9
MPCAX	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPCAX	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
OMITAX	11
PARAM	12
SUPAX	12
SUPORT	12
TEMP	13
TEMPAX	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
WTMASS	14
GRDPNT	15
PLOTEL	16
PLOT$	18
POUT$	19
XYOUT$	20
AOUT$	21
LOOP$	22
LOOP1$	23
COUPMASS	24
CPBAR	24
CPQDPLT	24
CPQUAD1	24
CPQUAD2	24
CPROD	24
CPTRBSC	24
CPTRIA1	24
CPTRIA2	24
CPTRPLT	24
CPTUBE	24
NOLOOP$	25

DIRECT FREQUENCY AND RANDOM RESPONSE

Card Name	Bit Pos.
RANDOM$	26
AXYOUT$	27
BDYLIST	52
FLSYM	52
RANDPS	55
RANDT1	55
RANDT2	55
TABRND1	54
TABRND2	54
TABRND3	54
TABRND4	54
G	56
EPOINT	57
SEQEP	57
TF	57
CVISC	58
PDAMP	59
PVISC	59
B2PP$	60
DMIAX	60
DMIG	60
K2PP$	60
M2PP$	60
TF$	60
DAREA	61
DELAY	61
DLOAD	61
DPHASE	61
FREQ	61
FREQ1	61
FREQ2	61
RLOAD1	61
RLOAD2	61
TABLED1	61
TABLED2	61
TABLED3	61
TABLED4	61
DECOMOPT	62
DLOAD$	62
FREQ$	62

3.9.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
K4GG	98
KGGX	98
BGG	99
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
BNN	104
K4NN	104
KNN	104
MNN	104
BFF	105
K4FF	105
KFF	105
KFS	105
MFF	105
GO	106
KAA	106
DLT	107
EQDYN	107
FRL	107
GPLD	107
PSDL	107
SILD	107
TFPOOL	107
USETD	107
CASEXX	108
B2PP	109
K2PP	109
M2PP	109

File Name	Bit Pos.
B2DD	110
BDD	110
GMD	110
GOD	110
K2DD	110
KDD	110
M2DD	110
MDD	110
PDF	111
PPF	111
PSF	111
UDVF	111
OUDVC1	112
OUDVC2	113
QPC	114
UPVC	114
OEFC1	115
OESC1	115
OPPC1	115
OQPC1	115
OUPVC1	115
OEFC2	116
OESC2	116
OPPC2	116
OQPC2	116
OUPVC2	116
AUTO	117
PSDF	117
BDPOOL	118
ABFL	119
KBFL	119
ELSETS	120
GPSETS	120
PLTPAR	120
PLTSETX	120
MAA	121
BAA	122
K4AA	123

3.9.3.3 Card Name Restart Table

```
DMAP                          Bit Position
Inst.     1        10        20        30        40        50        60

BEGIN     1234567890123456 8901234                           2 456789012
FILE      1234567890123456 8901234                           2 456789012
GP1       1
SAVE      1
PURGE     1
CHKPNT    1
COND      1
GP2       12 45          6                                          8
CHKPNT    12 45          6                                          8
PLTSET                     8
SAVE                       8
PRTMSG                     8
SETVAL                     8
SAVE                       8
COND                       8
PLOT                       8
SAVE                       8
PRTMSG                     8
LABEL                      8
CHKPNT                     8
GP3       1           3
CHKPNT    1           3
TA1,      1234567     3                                            89
SAVE      1234567     3                                            89
PURGE     1234567     3                                            89
CHKPNT    1234567     3                                            89
COND      123 5678    345
SMA1      123  6 8
SAVE      123  6 8
PURGE     123  6 8
CHKPNT    123  6 8
SMA2      123 5 78     4         4                                 89
SAVE      123 5 78     4         4                                 89
PURGE     123 5 78     4         4                                 89
CHKPNT    123 5 78     4         4                                 89
COND      123 5 78     45        4
COND      123 5 78     45        4
GPWG      123 5 78     45        4
OFP       123 5 78     45        4
SAVE      123 5 78     45        4
LABEL     123 5 78     45        4
EQUIV     1234 6 8
CHKPNT    1234 6 8
COND      1234 6 8
SMA3      1234 6 8
CHKPNT    1234 6 8
LABEL     1234 6 8
PARAM     1       901
GP4       1       901
SAVE      1       901
PURGE     1       901
EQUIV     123456789    4         4
CHKPNT    12345678901  4         4
COND      123  6 8 0
COND      123  6 890
GPSP      123  6 890
OFP       123  6 890
```

RIGID FORMATS

Bit Position

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						
MCE2	123456789	4	4			89	
CHKPNT	123456789	4	4			89	
LABEL	123456789	4	4			89	
EQUIV	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
COND	1234567890	4	4			89	
SCE1	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
LABEL	1234567890	4	4			89	
EQUIV	1234567890	1 4	4			89	
CHKPNT	1234567890	1 4	4			89	
COND	1234567890	1 4	4			89	
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
COND	1234567890	1 4	4				
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
COND	1234 6 890	1				89	
SMP2	1234 6 890	1				89	
CHKPNT	1234 6 890	1				89	
LABEL	1234 6 890	1				89	
COND	1234 6 890	1					
SMP2	1234 6 890	1					
CHKPNT	1234 6 890	1					
LABEL	1234567890	1 4	4			89	
DPD	1 90	1				5 7	1
SAVE	1 90	1				5 7	1
EQUIV	1234567890	1 4	234			2 67890	
CHKPNT	1 90	1				5 7	1
PARAM			23				
PARAM	1234567890	1234 6	23			2 4567890	12
BMG	1					2	
SAVE	1					2	
PARAM	1		23			2 7 0	
PURGE	1					2	
COND	1					2	
MTRXIN	1					2	
SAVE	1					2	
LABEL	1					2	
CHKPNT	1					2	
JUMP			23				
$SS	1 3						
LABEL	1234567890	123456 890	123			2 67890	12
$SS	1 3						
PURGE			23				
CASE	1234567890	1234 6 9	123 5			2 4567890	12
SAVE	1234567890	1234 6 9	123 5			2 4567890	12
CHKPNT	1234567890	1234 6 9	123 5			2 4567890	12
MTRXIN	1		23			2 7 0	
SAVE	1		23			2 7 0	
PARAM	1		23			2 7 0	

```
DMAP                           Bit Position
Inst.    1        10        20        30        40        50        60

PARAM    1                    23                            2    7  0
EQUIV    1                    23                            2    7  0
COND     1                    23                            2    7  0
EQUIV    1                    23                            2    7  0
COND     1                    23                            2    7  0
ADD      1                    23                            2    7  0
LABEL    1                    23                            2    7  0
EQUIV    1                    23                            2    7  0
COND     1                    23                            2    7  0
ADD      1                    23                            2    7  0
TRNSP    1                    23                            2    7  0
ADD      1                    23                            2    7  0
LABEL    1                    23                            2    7  0
PARAM    1                    23                            2    7  0
PARAM    1                    23                            2    7  0
PARAM    1                    23                            2    7  0
PURGE    12345678901  4       234                           2   67890
EQUIV    12345678901  4       234                           2   67890
CHKPNT   12345678901  4       234                           2   67890
COND     12345678901  4       234                           2   67890
GKAD     12345678901  4       234                           2   67890
LABEL    12345678901  4       234                           2   67890
EQUIV    12345678901  4       234                           2   67890
CHKPNT   12345678901  4       234                           2   67890
COND     12345678901  4       234                           2   6789012
COND     12345678901  4       234                           2   6789012
FRRD     12345678901  4       234                           2   6789012
EQUIV    12345678901  4       234                           2   6789012
CHKPNT   12345678901  4       234                           2   6789012
VDR                        901     7
SAVE                       901     7
COND                         1     7
COND                         1     7
CHKPNT                       1     7
SDR3                         1     7
OFP                          1
SAVE                         1
CHKPNT                       1     7
XYTRAN                             7
SAVE                               7
XYPLOT                             7
JUMP                         1     7
LABEL                        1     7
OFP                          1
SAVE                         1
LABEL                        1     7
COND     12345678901  4       234                           2   6789012
EQUIV    12345678901  4       234                           2   6789012
COND     12345678901  4       234                           2   6789012
SDR1     12345678901  4       234                           2   6789012
LABEL    12345678901  4       234                           2   6789012
CHKPNT   12345678901  4       234                           2   6789012
SDR2                       90
SAVE                       90
COND                       90
SDR3                       90
CHKPNT                     90
```

```
DMAP                         Bit Position
Inst.     1        10        20        30        40        50        60

OFP                         9
SAVE                        9
XYTRAN                       0
SAVE                         0
XYPLOT                       0
COND                         0                                 45
RANDOM                             6                           45
SAVE                               6                           45
CHKPNT                             6
COND                         0     6                           45
XYTRAN                       0
SAVE                         0
XYPLOT                       0
JUMP                         0
LABEL                       9
OFP                         9
SAVE                        9
LABEL                        0
COND                          23
$SS       1 3
REPT                          23
$SS       1 3
JUMP                          23
$SS       1 3
JUMP      1234567890123456 8901234                           2   6789012
LABEL                         23
$SS       1 3
PRTPARM                       23
$SS       1 3
LABEL     1234567890123456 8901234                           2   6789012
PRTPARM   1234567890123456 8901234                           2   6789012
LABEL     1234567890123456 8901234                           2   6789012
PRTPARM   1234567890123456 8901234                           2   6789012
LABEL     1234567890123456 8901234                           2   6789012
PRTPARM   1234567890123456 8901234                           2   6789012
LABEL     1234567890123456 8901234                           2   6789012
END       1234567890123456 8901234                           2   6789012
```

3.9.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 70 80
BEGIN	3456789 1234
FILE	3456789 1234
GP1	
SAVE	
PURGE	
CHKPNT	
COND	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
PURGE	
CHKPNT	
COND	
SMA1	
SAVE	
PURGE	
CHKPNT	
SMA2	3 678
SAVE	3 678
PURGE	3 678
CHKPNT	3 678
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PURGE	
EQUIV	
CHKPNT	
COND	
COND	
GPSP	
OFP	

DMAP Inst.	Bit Position 63 70 80
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
DPD	
SAVE	
EQUIV	
CHKPNT	
PARAM	
PARAM	3456789 1234
BMG	
SAVE	
PARAM	
PURGE	
COND	
MTRXIN	
SAVE	
LABEL	
CHKPNT	
JUMP	3456789 1234
LABEL	3456789 1234
PURGE	
CASE	3456789 1234
SAVE	3456789 1234
CHKPNT	3456789 1234
MTRXIN	
SAVE	
PARAM	
PARAM	
EQUIV	

DMAP Inst.	Bit Position 63 70 80
COND	
EQUIV	
COND	
ADD	
LABEL	
EQUIV	
COND	
ADD	
TRNSP	
ADD	
LABEL	
PARAM	
PARAM	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	1
GKAD	1
LABEL	1
EQUIV	
CHKPNT	
COND	3456789 1234
COND	3456789 1234
FRRD	
EQUIV	
CHKPNT	
VDR	
SAVE	
COND	
COND	
CHKPNT	
SDR3	
OFP	
SAVE	
CHKPNT	
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	
OFP	
SAVE	
LABEL	
COND	3456789 1234
EQUIV	3456789 1234
COND	3456789 1234
SDR1	3456789 1234
LABEL	3456789 1234
CHKPNT	3456789 1234
SDR2	
SAVE	
COND	
SDR3	
CHKPNT	
OFP	
SAVE	

DMAP Inst.	Bit Position 63 70 80
XYTRAN	
SAVE	
XYPLOT	
COND	3456789 1234
RANDOM	3456789 1234
SAVE	3456789 1234
CHKPNT	3456789 1234
COND	
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	
OFP	
SAVE	
LABEL	
COND	3456789 1234
REPT	3456789 1234
JUMP	3456789 1234
JUMP	3456789 1234
LABEL	3456789 1234
PRTPARM	3456789 1234
LABEL	3456789 1234
PRTPARM	3456789 1234
LABEL	3456789 1234
PRTPARM	3456789 1234
LABEL	3456789 1234
PRTPARM	3456789 1234
LABEL	3456789 1234
END	3456789 1234

3.9.3.5 File Name Restart Table

DMAP Inst.	94	100 (Bit Position)	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
PURGE				
CHKPNT				
COND				
GP2	5			
CHKPNT	5			
PLTSET				0
SAVE				0
PRTMSG				0
SETVAL				0
SAVE				0
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				0
GP3	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
PURGE	789	2 456		123
CHKPNT	7			
COND	8			
SMA1	8			
SAVE	8			
PURGE	8			
CHKPNT	8			
SMA2	9			
SAVE	9			
PURGE	9			
CHKPNT	9			
COND				
COND				
GPWG				
OFP				
SAVE				
LABEL	8			
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
PURGE		1 3 56	01 4	
EQUIV		4		
CHKPNT				
COND		2		
COND		2		
GPSP		2		
OFP		2		

DMAP Inst.	94	100 (Bit Position)	110	120
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		123
CHKPNT		6		123
COND		6		123
SMP1		6		
CHKPNT		6		
COND				1
SMP2				1
CHKPNT				1
LABEL				1
COND				2
SMP2				2
CHKPNT				2
LABEL				2
COND				3
SMP2				3
CHKPNT				3
LABEL		6		123
DPD		7		
SAVE		7		
EQUIV			0	
CHKPNT		7		
PARAM				
PARAM		8		
BMG			8	
SAVE			8	
PARAM		9	9	
PURGE			8	
COND			9	
MTRXIN			9	
SAVE			9	
LABEL			9	
CHKPNT			9	
JUMP		8		
LABEL		8		
PURGE				
CASE		8		
SAVE		8		
CHKPNT		8		
MTRXIN		9		
SAVE		9		
PARAM		9		
PARAM		9		
EQUIV		9		

DMAP Inst.	Bit Position (94, 100, 110, 120)
COND	9
EQUIV	9
COND	9
ADD	9
LABEL	9
EQUIV	9
COND	9
ADD	9
TRNSP	9
ADD	9
LABEL	9
PARAM	9
PARAM	9
PARAM	9
PURGE	0
EQUIV	0
CHKPNT	0
COND	0
GKAD	0
LABEL	0
EQUIV	1
CHKPNT	1
COND	1
COND	1
FRRD	1
EQUIV	1
CHKPNT	1
VDR	2
SAVE	2
COND	2
COND	2
CHKPNT	2
SDR3	3
OFP	
SAVE	
CHKPNT	3
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	
OFP	
SAVE	
LABEL	
COND	4
EQUIV	4
COND	4
SDR1	4
LABEL	4
CHKPNT	4
SDR2	5
SAVE	5
COND	6
SDR3	6
CHKPNT	6
OFP	
SAVE	

DMAP Inst.	Bit Position (94, 100, 110, 120)
XYTRAN	
SAVE	
XYPLOT	
COND	7
RANDOM	7
SAVE	7
CHKPNT	7
COND	
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	6
OFP	
SAVE	
LABEL	4
COND	
REPT	
JUMP	
JUMP	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
END	

3.9.4 Case Control Deck and Parameters for Direct Frequency and Random Response

The following items relate to subcase definition and data selection for Direct Frequency and Random Response:

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.

2. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading conditions - one subcase for each dynamic loading condition.

3. Constraints must be defined above the subcase level.

4. DLØAD must be used to define a frequency-dependent loading condition for each subcase.

5. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck for each unique set of direct input matrices.

6. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and FREQUENCY must be changed to select a FREQ, FREQ1, or FREQ2 card that reflects any frequencies for which the response has already been determined. Otherwise the previous calculations will be repeated.

7. ØFREQUENCY may be used above the subcase level or within each subcase to select a subset of the solution frequencies for output requests. The default is to use all solution frequencies.

8. If Random Response calculations are desired, RANDØM must be used to select RANDPS and RANDTi cards from the Bulk Data Deck. Only one ØFREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The following printed output, sorted by frequency (SØRT1) or by point number or element number (SØRT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by ØFREQUENCY:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements (ALL available only for SØRT1).

The following printed output is available for Random Response calculations:

1. Power spectral density function and mean deviation for the response of selected components for points or elements.

2. Autocorrelation function for the response of selected components for points or elements.

The following plotter output is available for Frequency Response calculations:

1. Undeformed plot of the structural model.

2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

3. X-Y Plot of any component of the applied load vector or single-point force of constraint.

4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Frequency Response calculations:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

5. DECØMØPT - optional for frequency response problems. The integer value of this parameter is used to control the type of arithmetic used in the decomposition of the dynamic equations. A value of 1 (default) means that double precision, complex arithmetic with partial pivoting will be used. A value of 2 means that double precision, complex arithmetic without pivoting will be used. A value of 4 means that single precision, complex arithmetic without pivoting will be used.

3.10 DIRECT TRANSIENT RESPONSE

3.10.1 DMAP Sequence for Direct Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN    NO.9 DIRECT TRANSIENT RESPONSE ANALYSIS - SERIES M1 $

  2  FILE     KGGX=TAPE/ KGG=TAPE $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
              123/V,N,NOGPDT $

  4  SAVE     LUSET,NOGPDT $

  5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,
              GPSETS,ELSETS/NOGPDT $

  6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
              PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

  7  COND     LBL5,NOGPDT $

  8  GP2      GEOM2,EQEXIN/ECT $

  9  CHKPNT   ECT $

 10  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT = -1 $

 11  SAVE     NSIL,JUMPPLOT $

 12  PRTMSG   PLTSETX// $

 13  SETVAL   //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 14  SAVE     PLTFLG,PFILE $

 15  COND     P1,JUMPPLOT $

 16  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 17  SAVE     JUMPPLOT,PLTFLG,PFILE $

 18  PRTMSG   PLOTX1// $

 19  LABEL    P1 $

 20  CHKPNT   PLTPAR,GPSETS,ELSETS $

 21  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 22  CHKPNT   GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 23  TA1,     ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
              123/V,N,NOSIMP=-1/C,N,0/V,N,NOGENL=-1/V,N,GENEL $

 24  SAVE     NOSIMP,NOGENL,GENEL $

 25  PURGE    K4GG,GPST,OGPST,MGG,BGG,  K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,
              BAA,KGGX/NOSIMP/ OGPST/GENEL $

 26  CHKPNT   EST,ECPT,GPCT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,
              K4AA,MNN,MFF,MAA,BNN,BFF,BAA $

 27  COND     LBL1,NOSIMP $

 28  SMA1     CSTM,MPT,ECPT,GPCT, DIT/KGGX,K4GG,GPST/V,N,NOGENL/ V,N,NOK4GG $

 29  SAVE     NOK4GG $

 30  PURGE    K4NN,K4FF,K4AA/NOK4GG $

 31  CHKPNT   KGGX,GPST,K4GG,K4NN,K4FF,K4AA $

 32  SMA2     CSTM,MPT,ECPT,GPCT,DIT/MGG,BGG/V,Y,WTMASS=1.0/V,N,NOMGG/   V,N,
              NOBGG=-1/V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/  V,Y,
              CPQUAD2/V,Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/ V,Y,
              CPTRPLT/V,Y,CPTRBSC $

 33  SAVE     NOMGG,NOBGG $

 34  PURGE    BNN,BFF,BAA/NOBGG/MNN,MFF,MAA/NOMGG $

 35  CHKPNT   MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $

 36  COND     LBL1,GRDPNT $

 37  COND     ERROR3,NOMGG $

 38  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 39  OFP      OGPWG,,,,,//V,N,CARDNO $

 40  SAVE     CARDNO $

 41  LABEL    LBL1 $

 42  EQUIV    KGGX,KGG/NOGENL $

 43  CHKPNT   KGG $

 44  COND     LBL11,NOGENL $

 45  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 46  CHKPNT   KGG $

 47  LABEL    LBL11 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
          N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48   PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 49   GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1=-1/
                V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/V,N,REACT=-1/V,N,NSKIP/
                V,N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

 50   SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $

 51   PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST,QP/SINGLE $

 52   EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $

 53   CHKPNT    GM,GMD,RG,GO,GOD,KFS,PST,QP,USET,KNN,MNN,BNN,K4NN $

 54   COND      LBL4,GENEL $

 55   COND      LBL4,NOSIMP $

 56   GPSP      GPL,GPST,USET,SIL/OGPST $

 57   OFP       OGPST,,,,,//V,N,CARDNO $

 58   SAVE      CARDNO $

 59   LABEL     LBL4 $

 60   COND      LBL2,MPCF1 $

 61   MCE1      USET,RG/GM $

 62   CHKPNT    GM $

 63   MCE2      USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $

 64   CHKPNT    KNN,MNN,BNN,K4NN $

 65   LABEL     LBL2 $

 66   EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $

 67   CHKPNT    KFF,MFF,BFF,K4FF $

 68   COND      LBL3,SINGLE $

 69   SCE1      USET,KNN,MNN,BNN,K4NN/KFF,KFS, ,MFF,BFF,K4FF $

 70   CHKPNT    KFS,KFF,MFF,BFF,K4FF $

 71   LABEL     LBL3 $

 72   EQUIV     KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT$
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  CHKPNT   KAA,MAA,BAA,K4AA $

 74  COND     LBL5,OMIT $

 75  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 76  CHKPNT   GO,KAA $

 77  COND     LBLM,NOMGG $

 78  SMP2     USET,GO,MFF/MAA $

 79  CHKPNT   MAA $

 80  LABEL    LBLM $

 81  COND     LBLB,NOBGG $

 82  SMP2     USET,GO,BFF/BAA $

 83  CHKPNT   BAA $

 84  LABEL    LBLB $

 85  COND     LBL5,NOK4GG $

 86  SMP2     USET,GO,K4FF/K4AA $

 87  CHKPNT   K4AA $

 88  LABEL    LBL5 $

 89  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,,
              EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/  V,
              N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 90  SAVE     LUSETD,NODLT,NONLFT,NOTRL,NOUE $

 91  PURGE    PNLD/NONLFT$

 92  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

 93  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,GOD,GMD,NLFT,PNLD,SILD,GPLD $

 94  BMG      MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
              MFACT $

 95  SAVE     MFACT,NOKBFL,NOABFL $

 96  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

 97  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 98  COND      LBLFL3,NOFL $

 99  MTRXIN,   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
               N,0 $

100  SAVE      NOABFL,NOKBFL $

101  LABEL     LBLFL3 $

102  CHKPNT    ABFL,KBFL $

103  MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
               NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

104  SAVE      NOK2DPP,NOM2DPP,NOB2PP $

105  PARAM     //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

106  PARAM     //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

107  EQUIV     K2DPP,K2XPP/NOKBFL/ M2DPP,M2PP/NOABFL $

108  COND      LBLFL1,NOKBFL $

109  EQUIV     KBFL,K2XPP/NOK2DPP $

110  COND      LBLFL1,NOK2DPP $

111  ADD       KBFL,K2DPP/K2XPP $

112  LABEL     LBLFL1 $

113  EQUIV     K2XPP,K2PP/NOABFL $

114  COND      LBLFL2,NOABFL $

115  ADD       ABFL,K2XPP/K2PP/C,N,(-1.0,0.0) $

116  TRNSP     ABFL/ABFLT $

117  ADD       ABFLT,M2DPP/M2PP/V,N,MFACT $

118  LABEL     LBLFL2 $

119  PARAM     //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

120  PARAM     //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

121  PARAM     //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

122  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

123  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/  KAA,
              KDD/KDEKA $

124  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD,KDD $

125  COND     LBL16,NOGPDT $

126  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,TRANRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,
              MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,
              KDEK2/C,N,-1 $

127  LABEL    LBL16 $

128  EQUIV    M2DD,MDD/NOSIMP/B2DD,BDD/NOGPDT/K2DD,KDD/KDEK2 $

129  CHKPNT   KDD,BDD,MDD,GMD,GOD $

130  COND     ERROR1,NOTRL $

131  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

132  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

133  JUMP     LBL13 $
                                                  Top of DMAP Loop
------------------------------------------------
134  LABEL    LBL13 $

135  PURGE    PNLD,OUDV1,OPNL1,OUDV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
              OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT/NEVER $

136  CASE     CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $

137  SAVE     REPEATT,NOLOOP $

138  CHKPNT   CASEXX $

139  TRD      CASEXX,USETD,DLT,TRL,NLFT,DIT,KDD,BDD,MDD,GMD,GOD,/UDVT,PDT,
              PST PPT,PNLD/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/C,N,0/V,N,NOUE/C,N,0 $

140  EQUIV    PPT,PDT/NOSET $

141  CHKPNT   UDVT,PDT,PST,PPT,PNLD $

142  VDR      CASEXX,EQDYN,USETD,UDVT,PPT,XYCDB,PNLD/OUDV1,OPNL1/ C,N,
              TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $

143  SAVE     NOD,NOP $

144  CHKPNT   OUDV1,OPNL1 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

145  COND    LBL15,NOD $

146  SDR3    OUDV1,OPNL1,,,,/OUDV2,OPNL2,,,, $

147  OFP     OUDV2,OPNL2,,,,//V,N,CARDNO $

148  SAVE    CARDNO $

149  CHKPNT  OPNL2,OUDV2 $

150  XYTRAN  XYCDB,OUDV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,DSET/V,N,PFILE/V,N,
             CARDNO $

151  SAVE    PFILE,CARDNO $

152  XYPLOT  XYPLTTA// $

153  LABEL   LBL15 $

154  PARAM   //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

155  COND    LBL18,PJUMP $

156  EQUIV   UDVT,UPV/NOA $

157  COND    LBL17,NOA $

158  SDR1    USETD,,UDVT,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $

159  LABEL   LBL17 $

160  CHKPNT  UPV,QP $

161  SDR2    CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,PPT,QP,UPV,EST,XYCDB/
             OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $

162  SDR3    OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $

163  CHKPNT  OPP2,OQP2,OUPV2,OES2,OEF2 $

164  OFP     OPP2,OQP2,OUPV2,OEF2,OES2,//V,N,CARDNO $

165  SAVE    CARDNO $

166  COND    P2,JUMPPLOT $

167  PLOT    PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV/PLOTX2/ V,N,
             NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

168  SAVE    PFILE $

169  PRTMSG  PLOTX2// $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

170  LABEL    P2 $

171  XYTRAN   XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $

172  SAVE     PFILE,CARDNO $

173  XYPLOT   XYPLTT// $

174  LABEL    LBL18 $

175  COND     FINIS,REPEATT $

176  REPT     LBL13,100 $                                Bottom of DMAP Loop
--------------------------------------------------------
177  JUMP     ERROR2 $

178  JUMP     FINIS $

179  LABEL    ERROR2 $

180  PRTPARM  //C,N,-2/C,N,DIRTRD $

181  LABEL    ERROR1 $

182  PRTPARM  //C,N,-1/C,N,DIRTRD $

183  LABEL    ERROR3 $

184  PRTPARM  //C,N,-3/C,N,DIRTRD $

185  LABEL    FINIS $

186  $

186  END      $
```

3.10.2 Description of DMAP Operations for Direct Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

7. Go to DMAP No. 88 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plot request.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

27. Go to DMAP No. 41 if there are no structural elements.

28. SMA1 generates stiffness matrix $[K^x_{gg}]$, structural damping matrix $[K^4_{gg}]$ and Grid Point Singularity Table.

32. SMA2 generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.

36. Go to DMAP No. 41 if no weight and balance request.

37. Go to DMAP No. 183 and print error message if no mass matrix exists.

38. GPWG generates weight and balance information.

39. ØFP formats weight and balance information and places it on the system output file for printing.

42. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

44. Go to DMAP No. 47 if no general elements.

45. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

49. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

52. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

54. Go to DMAP No. 59 if general elements present.

55. Go to DMAP No. 59 if no structural elements.

56. GPSP determines if possible grid point singularities remain.

57. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

60. Go to DMAP No. 65 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

61. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

63. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G_m^T][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G_m^T][K^4_{mm}][G_m].$$

66. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

68. Go to DMAP No. 71 if no single-point constraints.

69. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \qquad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right]$$

72. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

74. Go to DMAP No. 88 if no omitted coordinates.

75. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = [K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

77. Go to DMAP No. 80 if no mass matrix.

78. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G^T_o][M_{oo}][G_o]$$

81. Go to DMAP No. 84 if no viscous damping matrix.

82. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G^T_o][B_{oo}][G_o]$$

85. Go to DMAP No. 88 if no structural damping matrix.

86. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G^T_o][K^4_{oo}][G_o]$$

89. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Nonlinear Function Table and Transient Response List.

92. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

94. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

98. Go to DMAP No. 101 if no fluid structure interface is defined.

99. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

103. MTRXIN selects the direct input matrices $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^{2}_{pp}]$.

107. Equivalence $[K^{2d}_{pp}]$ to $[K^{2x}_{pp}]$ if no $[K_{b,f\ell}]$ and $[M^{2d}_{pp}]$ to $[M^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

108. Go to DMAP No. 112 if no $[K_{b,f\ell}]$.

109. Equivalence $[K_{b,f\ell}]$ to $[K^{2x}_{pp}]$ if no $[K^{2d}_{pp}]$.

110. Go to DMAP No. 105 if no $[K^{2d}_{pp}]$.

111. ADD assembles matrix $[K^{2x}_{pp}] = [K_{b,f\ell}] + [K^{2d}_{pp}]$.

113. Equivalence $[K^{2x}_{pp}]$ to $[K^{2}_{pp}]$ if no $[A_{b,f\ell}]$.

114. Go to DMAP No. 118 if no $[A_{b,f\ell}]$.

115. ADD substracts $[A_{b,f\ell}]$ from $[K^{2x}_{pp}]$ to obtain $[K^{2}_{pp}]$.

116. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

117. ADD assembles input matrix $[M^{2}_{pp}] = \text{MFACT}\ [A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

123. Equivalence $[M^{2}_{pp}]$ to $[M^{2}_{dd}]$, $[B^{2}_{pp}]$ to $[B^{2}_{dd}]$ and $[K^{2}_{pp}]$ to $[K^{2}_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ if no direct input damping matrices and no extra points.

125. Go to DMAP No. 127 if only extra points defined.

126. GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response

$$[K_{dd}] = [K^{1}_{dd}] + [K^{2}_{dd}],$$
$$[M_{dd}] = [M^{1}_{dd}] + [M^{2}_{dd}] \text{ and}$$
$$[B_{dd}] = [B^{1}_{dd}] + [B^{2}_{dd}] + \frac{g}{\omega_3}[K^{1}_{dd}] + \frac{1}{\omega_4}[K^{4}_{dd}].$$

All matrices are real.

128. Equivalence $[B^{2}_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M^{2}_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K^{2}_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input.

130. Go to DMAP No. 181 and print error message if no Transient Response List.

133. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

134. Beginning of loop for additional dynamic load sets.

136. CASE extracts user requests from CASECC for current loop.

139. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P_d^{n\ell}\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = \{P_d\} + \{P_d^{n\ell}\} .$$

140. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

142. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the independent degrees of freedom.

145. Go to DMAP No. 153 if no output request for the independent degrees of freedom.

146. SDR3 sorts the independent displacements, velocities, accelerations and nonlinear load vectors by point number.

147. ØFP formats the requested independent displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.

150. XYTRAN prepares the input for X-Y plotting of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

152. XYPLØT prepares requested X-Y plots of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

155. Go to DMAP No. 174 if no output request involving dependent degrees of freedom or forces and stresses.

156. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

157. Go to DMAP No. 159 if no constraints applied.

158. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} , \qquad \begin{Bmatrix} u_d \\ \hline u_o \end{Bmatrix} = \{u_f + u_e\} ,$$

$$\begin{Bmatrix} u_f + u_e \\ \hline u_s \end{Bmatrix} = \{u_n + u_e\} , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} ,$$

$$\begin{Bmatrix} u_n + u_e \\ \hline u_m \end{Bmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [\bar{K}_{fs}^T]\{u_f\}$.

161. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output (ØPP1, ØUPV1, PUGV, ØQP1) - all sorted by time step.

162. SDR3 prepares requested output sorted by point number or element number.

164. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.

166. Go to DMAP No. 170 if no deformed structure plots requested.

167. PLØT prepares all requested deformed structure plots.

169. PRTMSG prints plotter data and engineering data for each deformed plot generated.

171. XYTRAN prepares the input for requested X-Y plots.

173. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.

175. Go to DMAP No. 185 if no additional dynamic load sets need to be processed.

176. Go to DMAP No. 134 if additional dynamic load sets need to be processed.

177. Go to DMAP No. 179 and print error message if more than 100 loops.

178. Go to DMAP No. 185 and make normal exit.

180. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

182. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

184. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.10.3 Restart Tables for Direct Transient Response

3.10.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CONROD	2	MAT2	8
ADUM2	1	CQDMEM	2	MAT3	8
ADUM3	1	CQDMEM1	2	MATT1	8
ADUM4	1	CQDMEM2	2	MATT2	8
ADUM5	1	CQDMEM3	2	MATT3	8
ADUM6	1	CQDPLT	2	TABLEM1	8
ADUM7	1	CQUAD1	2	TABLEM2	8
ADUM8	1	CQUAD2	2	TABLEM3	8
ADUM9	1	CROD	2	TABLEM4	8
AXIC	1	CSHEAR	2	TEMPMT$	8
AXIF	1	CTETRA	2	TEMPMX$	8
CDAMP1	1	CTORDRG	2	AXISYM$	9
CDAMP2	1	CTRAPRG	2	MPC	9
CDAMP3	1	CTRBSC	2	MPCADD	9
CDAMP4	1	CTRIA1	2	MPCAX	9
CELAS1	1	CTRIA2	2	MPC$	9
CELAS2	1	CTRIARG	2	SPC	10
CELAS3	1	CTRMEM	2	SPC1	10
CELAS4	1	CTRPLT	2	SPCADD	10
CMASS1	1	CTUBE	2	SPCAX	10
CMASS2	1	CTWIST	2	SPC$	10
CMASS3	1	CWEDGE	2	ASET	11
CMASS4	1	PBAR	3	ASET1	11
CORD1C	1	PCONEAX	3	OMIT	11
CORD1R	1	PDUM1	3	OMIT1	11
CORD1S	1	PDUM2	3	OMITAX	11
CORD2C	1	PDUM3	3	SUPAX	12
CORD2R	1	PDUM4	3	SUPORT	12
CORD2S	1	PDUM5	3	TEMP	13
FREEPT	1	PDUM6	3	TEMPAX	13
GRDSET	1	PDUM7	3	TEMPD	13
GRID	1	PDUM8	3	TEMPP1	13
GRIDB	1	PDUM9	3	TEMPP2	13
POINTAX	1	PQDMEM	3	TEMPP3	13
PRESPT	1	PQDMEM1	3	TEMPRB	13
RINGAX	1	PQDMEM2	3	WTMASS	14
RINGFL	1	PQDMEM3	3	GRDPNT	15
SECTAX	1	PQDPLT	3	PLOTEL	16
SEQGP	1	PQUAD1	3	PLOT$	18
SPOINT	1	PQUAD2	3	POUT$	19
BAROR	2	PROD	3	XYOUT$	20
CBAR	2	PSHEAR	3	AOUT$	21
CCONEAX	2	PTORDRG	3	LOOP$	22
CDUM1	2	PTRBSC	3	LOOP1$	23
CDUM2	2	PTRIA1	3	COUPMASS	24
CDUM3	2	PTRIA2	3	CPBAR	24
CDUM4	2	PTRMEM	3	CPQDPLT	24
CDUM5	2	PTRPLT	3	CPQUAD1	24
CDUM6	2	PTUBE	3	CPQUAD2	24
CDUM7	2	PTWIST	3	CPROD	24
CDUM8	2	GENEL	4	CPTRBSC	24
CDUM9	2	CONM1	5	CPTRIA1	24
CFLUID2	2	CONM2	5	CPTRIA2	24
CFLUID3	2	FSLIST	5	CPTRPLT	24
CFLUID4	2	PELAS	6	CPTUBE	24
CHEXA1	2	PMASS	7	NOLOOP$	25
CHEXA2	2	MAT1	8	AXYOUT$	27

Card Name	Bit Pos.
BDYLIST	52
FLSYM	52
G	56
W3	56
W4	56
EPOINT	57
SEQEP	57
TF	57
CVISC	58
PDAMP	59
PVISC	59
DMIAX	60
DMIG	60
B2PP$	60
K2PP$	60
M2PP$	60
TF$	60
DAREA	61
DELAY	61
DLOAD	61
NOLIN1	61
NOLIN2	61
NOLIN3	61
NOLIN4	61
TABLED1	61
TABLED2	61
TABLED3	61
TABLED4	61
TIC	61
TLOAD1	61
TLOAD2	61
TSTEP	61
DLOAD$	62
IC$	62
NLFORCE	62
TSTEP$	62

3.10.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
K4GG	98
KGGX	98
BGG	99
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
BNN	104
K4NN	104
KNN	104
MNN	104
BFF	105
K4FF	105
KFF	105
KFS	105
MFF	105
GO	106
KAA	106
DLT	107
EQDYN	107
GPLD	107
NLFT	107
SILD	107
TFPOOL	107
TRL	107
USETD	107
CASEXX	108
B2PP	109
K2PP	109
M2PP	109

File Name	Bit Pos.
B2DD	110
BDD	110
GMD	110
GOD	110
K2DD	110
KDD	110
M2DD	110
MDD	110
PDT	111
PNLD	111
PPT	111
PST	111
UDVT	111
OUDV1	112
OPNL1	112
OUDV2	113
OPNL2	113
QP	114
UPV	114
OEF1	115
OES1	115
OPP1	115
OQP1	115
OUPV1	115
PUGV	115
OEF2	116
OES2	116
OPP2	116
OQP2	116
OUPV2	116
BDPOOL	118
ABFL	119
KBFL	119
ELSETS	120
GPSETS	120
PLTPAR	120
PLTSETX	120
MAA	121
BAA	122
K4AA	123

3.10.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 890	1234			2 67890	12
FILE	1234567890	123456 890	1234			2 67890	12
GP1	1						
SAVE	1						
PURGE	1						
CHKPNT	1						
COND	1						
GP2	12 45	6				8	
CHKPNT	12 45	6				8	
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	1	3					
CHKPNT	1	3					
TA1	1234567	3				89	
SAVE	1234567	3				89	
PURGE	1234567	3				89	
CHKPNT	1234567	3				89	
COND	123 5678	345	4				
SMA1	123 6 8						
SAVE	123 6 8						
PURGE	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4			89	
SAVE	123 5 78	4	4			89	
PURGE	123 5 78	4	4			89	
CHKPNT	123 5 78	4	4			89	
COND	123 5 78	45	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 7	45	4				
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	1					
GP4	1 90	1					
SAVE	1 90	1					
PURGE	1 90	1					
EQUIV	123456789	4	4				
CHKPNT	1234567890	1 4	4				
COND	123 6 8 0						
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						
MCE2	123456789	4	4			89	
CHKPNT	123456789	4	4			89	
LABEL	123456789	4	4			89	
EQUIV	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
COND	1234567890	4	4			89	
SCE1	1234567890	4	4			89	
CHKPNT	1234567890	4	4			89	
LABEL	1234567890	4	4			89	
EQUIV	1234567890	1 4	4			89	
CHKPNT	1234567890	1 4	4			89	
COND	1234567890	1 4	4			89	
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
COND	1234567890	1 4	4				
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
COND	1234 6 890	1				89	
SMP2	1234 6 890	1				89	
CHKPNT	1234 6 890	1				89	
LABEL	1234 6 890	1				89	
COND	1234 6 890	1					
SMP2	1234 6 890	1					
CHKPNT	1234 6 890	1					
LABEL	1234567890	1 4	4			89	
DPD	1 90	1				7	1
SAVE	1 90	1				7	1
PURGE	1					7	1
EQUIV	1234567890	1 4	4			2 67890	
CHKPNT	1 90	1				2 7 0	1
BMG	1					2	
SAVE	1					2	
PARAM	1					2 7 0	
PURGE	1					2	
COND	1					2	
MTRXIN	1					2	
SAVE	1					2	
LABEL	1					2	
CHKPNT	1					2	
MTRXIN	1					2 7 0	
SAVE	1					2 7 0	
PARAM	1					2 7 0	
PARAM	1					2 7 0	
EQUIV	1					2 7 0	
COND	1					2 7 0	
EQUIV	1					2 7 0	
COND	1					2 7 0	
ADD	1					2 7 0	
LABEL	1					2 7 0	
EQUIV	1					2 7 0	
COND	1					2 7 0	

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
ADD	1					2 7 0	
TRNSP	1					2 7 0	
ADD	1					2 7 0	
LABEL	1					2 7 0	
PARAM	1					2 7 0	
PARAM	1					2 7 0	
PARAM	1					2 7 0	
PURGE	1234567890	1 4	4			2 7890	
EQUIV	1234567890	1 4	4			2 7890	
CHKPNT	1234567890	1 4	4			2 7890	
COND	1234567890	1 4	4			2 7890	
GKAD	1234567890	1 4	4			2 67890	
LABEL	1234567890	1 4	4			2 67890	
EQUIV	1234567890	1 4	4			2 67890	
CHKPNT	1234567890	1 4	4			2 67890	
COND	1234567890	1 4	4			2 67890	
PARAM		4	234				
PARAM	1234567890	1234 6	234			2 67890	12
JUMP		4	234				
$SS	1 3						
LABEL	1234567890	123456 890	12345			2 67890	12
$SS	1 3						
PURGE		4	234				
CASE	1234567890	1234 6 9	12345			2 67890	12
SAVE	1234567890	1234 6 9	12345			2 67890	12
CHKPNT	1234567890	1234 6 9	12345			2 67890	12
TRD	1234567890	1 4	234			2 67890	12
EQUIV	1234567890	1 4	234			2 67890	12
CHKPNT	1234567890	1 4	234			2 67890	12
VDR		90	1 7				
SAVE		90	1 7				
CHKPNT			1 7				
COND			1 7				
SDR3			1 7				
OFP			1				
SAVE			1				
CHKPNT			1 7				
XYTRAN			7				
SAVE			7				
XYPLOT			7				
LABEL			1				
PARAM	1234567890	1 4	234			2 67890	12
COND	1234567890	1 4	234			2 67890	12
EQUIV	1234567890	1 4	234			2 67890	12
COND	1234567890	1 4	234			2 67890	12
SDR1	1234567890	1 4	234			2 67890	12
LABEL	1234567890	1 4	234			2 67890	12
CHKPNT	1234567890	1 4	234			2 67890	12
SDR2		890					
SDR3		890					
CHKPNT		890					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					

DIRECT TRANSIENT RESPONSE

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
LABEL		8					
XYTRAN		0					
SAVE		0					
XYPLOT		0					
LABEL		0					
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
JUMP	1234567890	123456 890	1234			2 67890	12
LABEL			23				
$SS	1 3						
PRTPARM			23				
$SS	1 3						
LABEL	1234567890	123456 890	1234			2 67890	12
PRTPARM	1234567890	123456 890	1234			2 67890	12
LABEL	1234567890	123456 890	1234			2 67890	12
PRTPARM	1234567890	123456 890	1234			2 67890	12
LABEL	1234567890	123456 890	1234			2 67890	12
END	1234567890	123456 890	1234			2 67890	12

3.10.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 70 80
BEGIN	34567890 234
FILE	34567890 234
GP1	
SAVE	
PURGE	
CHKPNT	
COND	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
PURGE	
CHKPNT	
COND	
SMA1	
SAVE	
PURGE	
CHKPNT	
SMA2	3 678
SAVE	3 678
PURGE	3 678
CHKPNT	3 678
COND	
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PURGE	
EQUIV	
CHKPNT	
COND	
COND	
GPSP	
OFP	

DMAP Inst.	Bit Position 63 70 80
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
DPD	
SAVE	
PURGE	
EQUIV	
CHKPNT	
BMG	
SAVE	
PARAM	
PURGE	
COND	
MTRXIN	
SAVE	
LABEL	
CHKPNT	
MTRXIN	
SAVE	
PARAM	
PARAM	
EQUIV	
COND	
EQUIV	
COND	
ADD	
LABEL	
EQUIV	
COND	

DMAP Inst.	Bit Position 63 70 80
ADD	
TRNSP	
ADD	
LABEL	
PARAM	
PARAM	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	90
GKAD	90
LABEL	90
EQUIV	
CHKPNT	
COND	34567890 234
PARAM	
PARAM	34567890 234
JUMP	34567890 234
LABEL	34567890 234
PURGE	
CASE	34567890 234
SAVE	34567890 234
CHKPNT	34567890 234
TRD	
EQUIV	
CHKPNT	
VDR	
SAVE	
CHKPNT	
COND	
SDR3	
OFP	
SAVE	
CHKPNT	
XYTRAN	
SAVE	
XYPLOT	
LABEL	
PARAM	34567890 234
COND	34567890 234
EQUIV	34567890 234
COND	34567890 234
SDR1	34567890 234
LABEL	34567890 234
CHKPNT	34567890 234
SDR2	
SDR3	
CHKPNT	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
XYTRAN	

DMAP Inst.	Bit Position 63 70 80
SAVE	
XYPLOT	
LABEL	
COND	34567890 234
REPT	34567890 234
JUMP	34567890 234
JUMP	34567890 234
LABEL	34567890 234
PRTPARM	34567890 234
LABEL	34567890 234
PRTPARM	34567890 234
LABEL	34567890 234
PRTPARM	34567890 234
LABEL	34567890 234
END	34567890 234

3.10.3.5 File Name Restart Table

DMAP Inst.	94	100	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
PURGE				
CHKPNT				
COND				
GP2	5			
CHKPNT	5			
PLTSET				0
SAVE				0
PRTMSG				0
SETVAL				0
SAVE				0
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				0
GP3	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
PURGE	789	2 456		123
CHKPNT	7			
COND	8			
SMA1	8			
SAVE	8			
PURGE	8			
CHKPNT	8			
SMA2	9			
SAVE	9			
PURGE	9			
CHKPNT	9			
COND				
COND				
GPWG				
OFP				
SAVE				
LABEL	8			
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
PURGE		1 3 56	01 4	
EQUIV		4		
CHKPNT				
COND		2		
COND		2		
GPSP		2		
OFP		2		

DMAP Inst.	94	100	110	120
SAVE				
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		123
CHKPNT		6		123
COND		6		123
SMP1		6		
CHKPNT		6		
COND				1
SMP2				1
CHKPNT				1
LABEL				1
COND				2
SMP2				2
CHKPNT				2
LABEL				2
COND				3
SMP2				3
CHKPNT				3
LABEL		6		123
DPD		7		
SAVE		7		
PURGE		7		
EQUIV			0	
CHKPNT		7		
BMG			8	
SAVE			8	
PARAM		9	9	
PURGE			8	
COND			9	
MTRXIN			9	
SAVE			9	
LABEL			9	
CHKPNT			9	
MTRXIN		9		
SAVE		9		
PARAM		9		
PARAM		9		
EQUIV		9		
COND		9		
EQUIV		9		
COND		9		
ADD		9		
LABEL		9		
EQUIV		9		
COND		9		

DIRECT TRANSIENT RESPONSE

DMAP Inst.	Bit Position (94 — 100 — 110 — 120)
ADD	9
TRNSP	9
ADD	9
LABEL	9
PARAM	9
PARAM	9
PARAM	9
PURGE	0
EQUIV	0
CHKPNT	0
COND	0
GKAD	0
LABEL	0
EQUIV	0
CHKPNT	0
COND	1
PARAM	
PARAM	8
JUMP	8
LABEL	8
PURGE	
CASE	8
SAVE	8
CHKPNT	8
TRD	1
EQUIV	1
CHKPNT	1
VDR	2
SAVE	2
CHKPNT	2
COND	3
SDR3	3
OFP	
SAVE	
CHKPNT	3
XYTRAN	
SAVE	
XYPLOT	
LABEL	
PARAM	4
COND	4
EQUIV	4
COND	4
SDR1	4
LABEL	4
CHKPNT	4
SDR2	5
SDR3	6
CHKPNT	6
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
XYTRAN	
SAVE	
XYPLOT	
LABEL	4
COND	
REPT	
JUMP	
JUMP	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
PRTPARM	
LABEL	
END	

3.10.4 Case Control Deck and Parameters for Direct Transient Response

The following items relate to subcase definition and data selection for Direct Transient Response:

1. One subcase must be defined for each dynamic loading condition.
2. DLØAD or NØNLINEAR must be used to define a time-dependent loading condition for each subcase.
3. Constraints must be defined above the subcase level.
4. TSTEP must be used to select the time-step intervals to be used for integration and output in each subcase.
5. If nonzero initial conditions are desired, IC must be used to select a TIC card in the Bulk Data Deck.
6. On restart following an unscheduled exit due to insufficient time, the subcase structure should be changed to reflect any completed loading conditions. The TSTEP selections must be changed if it is desired to resume the integration at the point terminated.

The following printed output, sorted by point number or element number (SØRT2) is available at selected multiples of the integration time step:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).
2. Nonzero components of the applied load vector and single point forces of constraint for a list of PHYSICAL points.
3. Nonlinear force vector for a list of SØLUTIØN points.
4. Stresses and forces in selected elements (All not allowed).

The following plotter output is available for Transient Response:

1. Undeformed plot of the structural model.
2. Deformed shapes of the structural model for selected time intervals.
3. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

4. X-Y plot of any component of the applied load vector, nonlinear force vector, or single-point force of constraint.

5. X-Y plot of any stress or force component for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Direct Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. W3 and W4 - optional - The values of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. W3 is required if uniform structural damping is desired. W4 is required if structural damping is desired for any of the structural elements. See page 9.3-8 of the NASTRAN Theoretical Manual.

5. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

3.11 MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.1 DMAP Sequence for Modal Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.10 MODAL COMPLEX EIGENVALUE ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE/ GOD=SAVE/ GMD=SAVE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

  9  SAVE      NSIL,JUMPPLOT $

 10  PRTMSG    PLTSETX// $

 11  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 12  SAVE      PLTFLG,PFILE $

 13  COND      P1,JUMPPLOT $

 14  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 15  SAVE      PFILE $

 16  PRTMSG    PLOTX1// $

 17  LABEL     P1 $

 18  CHKPNT    PLTPAR,GPSETS,ELSETS $

 19  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 20  CHKPNT    GPTT $

 21  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 22  SAVE      NOGENL,NOSIMP,GENEL $

 23  COND      ERROR1,NOSIMP $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```
24  PURGE    OGPST/GENEL $

25  CHKPNT   EST,ECPT,GPCT,GEI,OGPST $

26  SMA1     CSTM,MPT,ECPT,GPCT, DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

27  CHKPNT   KGGX,GPST $

28  SMA2     CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
             V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
             Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
             CPTRBSC $

29  SAVE     NOMGG $

30  COND     ERRCP1,NOMGG $

31  CHKPNT   MGG $

32  COND     LGPWG,GRDPNT $

33  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

34  OFP      OGPWG,,,,,//V,N,CARDNO $

35  SAVE     CARDNO $

36  LABEL    LGPWG $

37  EQUIV    KGGX,KGG/NOGENL $

38  CHKPNT   KGG $

39  COND     LBL11,NOGENL $

40  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

41  CHKPNT   KGG $

42  LABEL    LBL11 $

43  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

44  GP4      CASECC,GEOM4,EQEXIN,SIL,GPDT/RG, ,USET,/V,N,LUSET/V,N,MPCF1/V,
             N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
             V,N,NOSET/V,N,NOL/V,N,NOA $

45  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

46  PARAM    //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

47  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR,
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
              DM,MR/REACT $

 48  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 49  CHKPNT   KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,QPC,USET,KNN,MNN,GMD,GOD $

 50  COND     LBL4,GENEL $

 51  GPSP     GPL,GPST,USET,SIL/OGPST $

 52  OFP      OGPST,,,,,//V,N,CARDNO $

 53  SAVE     CARDNO $

 54  LABEL    LBL4 $

 55  COND     LBL2,MPCF1 $

 56  MCE1     USET,RG/GM $

 57  CHKPNT   GM $

 58  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

 59  CHKPNT   KNN,MNN $

 60  LABEL    LBL2 $

 61  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 62  CHKPNT   KFF,MFF $

 63  COND     LBL3,SINGLE $

 64  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 65  CHKPNT   KFS,KFF,MFF $

 66  LABEL    LBL3 $

 67  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $

 68  CHKPNT   KAA,MAA $

 69  COND     LBL5,OMIT $

 70  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 71  CHKPNT   GO,KAA $

 72  SMP2     USET,GO,MFF/MAA $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  CHKPNT   MAA $

 74  LABEL    LBL5 $

 75  COND     LBL6,REACT $

 76  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 77  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

 78  RBMG2    KLL/LLL,ULL $

 79  CHKPNT   ULL,LLL $

 80  RBMG3    LLL,ULL,KLR,KRR/DM $

 81  CHKPNT   DM $

 82  RBMG4    DM,MLL,MLR,MRR/MR $

 83  CHKPNT   MR $

 84  LABEL    LBL6 $

 85  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 86  SAVE     LUSETD,NOUE,NOEED $

 87  COND     ERROR2,NOEED $

 88  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

 89  CHKPNT   USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $

 90  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

 91  SAVE     NEIGV $

 92  CHKPNT   LAMA,PHIA,MI,OEIGS $

 93  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

 94  SAVE     CARDNO $

 95  COND     ERROR4,NEIGV $

 96  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

 97  PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  98   JUMP     LBL13 $
                                                      Top of DMAP Loop
  99   LABEL    LBL13 $

 100   PURGE    PHIH,CLAMA,OPHIH,CPHID,CPHIP,QPC,OQPC1,OCPHIP,OESC1,OEFC1,K2PP,
                M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

 101   CASE     CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

 102   SAVE     REPEATE,NOLOOP $

 103   CHKPNT   CASEXX $

 104   MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
                NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

 105   SAVE     NOK2PP,NOM2PP,NOB2PP $

 106   PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

 107   EQUIV    M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $

 108   CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

 109   GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
                CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
                N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/
                C,N,-1/C,N,-1/   C,N,-1/C,N,-1 $

 110   CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

 111   GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX / MHH,BHH,KHH,
                PHIDH/V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/   C,Y,HFREQ=0.0/V,N,
                NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/   V,N,FMODE $

 112   SAVE     NONCUP,FMODE $

 113   CHKPNT   MHH,BHH,KHH,PHIDH $

 114   CEAD     KHH,BHH,MHH,EED,CASEXX/PHIH,CLAMA,OCEIGS/V,N,EIGVS $

 115   SAVE     EIGVS $

 116   CHKPNT   PHIH,CLAMA,OCEIGS $

 117   OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $

 118   SAVE     CARDNO $

 119   COND     LBL17,EIGVS $

 120   VDR      CASEXX,EQDYN,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/V,
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
                    N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

121  SAVE      NOH,NOP $

122  COND      LBL16,NOH $

123  OFP       CPHIH,,,,,//V,N,CARDNO $

124  SAVE      CARDNO $

125  LABEL     LBL16 $

126  COND      LBL17,NOP $

127  DDR1      PHIH,PHIDH/CPHID $

128  CHKPNT    CPHID $

129  SDR1      USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS $

130  CHKPNT    CPHIP,QPC $

131  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,/,OQPC1,
               OCPHIP,OESC1,OEFC1, /C,N,CEIGEN $

132  OFP       OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $

133  SAVE      CARDNO $

134  LABEL     LBL17 $

135  COND      FINIS,REPEATE $

136  REPT      LBL13,100 $
-----------------------------------------------------  Bottom of DMAP Loop
137  JUMP      ERROR3 $

138  JUMP      FINIS $

139  LABEL     ERROR3 $

140  PRTPARM   //C,N,-3/C,N,MDLCEAD $

141  LABEL     ERROR2 $

142  PRTPARM   //C,N,-2/C,N,MDLCEAD $

143  LABEL     ERROR1 $

144  PRTPARM   //C,N,-1/C,N,MDLCEAD $

145  LABEL     ERROR4 $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 10

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

146  PRTPARM  //C,N,-4/C,N,MDLCEAD $

147  LABEL    FINIS $

148  END      $
```

3.11.2 Description of DMAP Operations for Modal Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

8. PLTSET transforms user input into a form used to drive structure plotter.

10. PRTMSG prints error messages associated with structure plotter.

13. Go to DMAP No. 17 if no undeformed structure plot request.

14. PLØT generates all requested undeformed structure plots.

16. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

19. GP3 generates Grid Point Temperature Table.

21. TA1 generates element tables for use in matrix assembly and stress recovery.

23. Go to DMAP No. 143 and print error message if there are no structural elements.

26. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

27. SMA2 generates mass matrix $[M_{gg}]$.

30. Go to DMAP No. 143 and print error message if no mass matrix exists.

32. Go to DMAP No. 36 if no weight and balance request.

33. GPWG generates weight and balance information.

34. ØFP formats weight and balance information and places it on the system output file for printing.

37. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

39. Go to DMAP No. 42 if no general elements.

40. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

44. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

48. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

50. Go to DMAP No. 54 if general elements present.

51. GPSP determines if possible grid point singularities remain.

52. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

55. Go to DMAP No. 60 if no multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 74 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

72. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] = [G_o^T][M_{oa}] = [G_o^T][M_{oo}][G_o] .$$

75. Go to DMAP No. 84 if no free-body supports.

76. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

78. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

80. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K^T_{\ell r}][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

82. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M^T_{\ell r}][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

85. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

87. Go to DMAP No. 141 and print error message if no Eigenvalue Extraction Data.

88. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

90. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi^T_{ro}][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \, \phi_{ro} \\ --- \\ \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi^T_a][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

93. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

95. Go to DMAP No. 145 and print error message if no eigenvalues found.

98. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

99. Beginning of loop for additional sets of direct input matrices.

101. CASE extracts user requests from CASECC for current loop.

104. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

107. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

109. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

111. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Complex Eigenvalue Analysis.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where m_i = modal masses

$$b_i = m_i\, 2\pi\, f_i\, g(f_i)$$

$$k_i = m_i\, 4\pi^2\, f_i^2$$

and direct input matrices may be complex.

114. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

117. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

119. Go to DMAP No. 134 if no complex eigenvalues found.

120. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.

122. Go to DMAP No. 125 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

123. ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.

126. Go to DMAP No. 134 if no output request involving dependent degrees of freedom or forces and stresses.

127. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d] = [\phi_{dh}][\phi_h].$$

129. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi_f + \phi_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f + \phi_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + \phi_e\} \quad , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n + \phi_e \\ \hline \phi_m\end{array}\right\} = \{\phi_p\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

131. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1).

132. ØFP formats tables prepared by SDR2 and places them on system output file for printing.

135. Go to DMAP No. 147 if no additional sets of direct input matrices need to be processed.

136. Go to DMAP No. 99 if additional sets of direct input matrices need to be processed.

137. Go to DMAP No. 139 and print error message if more than 100 loops.

138. Go to DMAP No. 147 and make normal exit.

140. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

142. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

144. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

146. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.11.3 Restart Tables for Modal Complex Eigenvalue Analysis

3.11.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
AXIC	1
AXIF	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CMASS1	1
CMASS2	1
CMASS3	1
CMASS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
GRDSET	1
GRID	1
GRIDB	1
POINTAX	1
RINGAX	1
RINGFL	1
SECTAX	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CCONEAX	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CHEXA1	2
CHEXA2	2
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQDPLT	2
CQUAD1	2
CQUAD2	2
CROD	2

Card Name	Bit Pos.
CSHEAR	2
CTETRA	2
CTORDRG	2
CTRAPRG	2
CTRBSC	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTRPLT	2
CTUBE	2
CTWIST	2
CWEDGE	2
PBAR	3
PCONEAX	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQDPLT	3
PQUAD1	3
PQUAD2	3
PROD	3
PSHEAR	3
PTORDRG	3
PTRBSC	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTRPLT	3
PTUBE	3
PTWIST	3
GENEL	4
CONM1	5
CONM2	5
PELAS	6
PMASS	7
MAT1	8
MAT2	8
MAT3	8
MATT1	8
MATT2	8
MATT3	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8

Card Name	Bit Pos.
TEMPMX$	8
AXISYM$	9
MPC	9
MPCADD	9
MPCAX	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPCAX	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
OMITAX	11
SUPAX	12
SUPORT	12
TEMP	13
TEMPAX	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
WTMASS	14
GRDPNT	15
PLOTEL	16
PLOT$	18
POUT$	19
AOUT$	21
LOOP$	22
LOOP1$	23
COUPMASS	24
CPBAR	24
CPDPLT	24
CPQUAD1	24
CPQUAD2	24
CPROD	24
CPTRBSC	24
CPTRIA1	24
CPTRIA2	24
CPTRPLT	24
CPTUBE	24
NOLOOP$	25
EPOINT	56
SEQEP	56
TF	56
DMIG	57
DMIAX	57
B2PP$	57
K2PP$	57
M2PP$	57
TF$	57
EIGR	58
METHOD$	59
EIGC	60

Card Name	Bit Pos.
EIGP	60
CMETHOD$	61
LFREQ	62
LMODES	62
HFREQ	62
SDAMP$	62
TABDMP1	62

3.11.3.4 Bit Positions for File Name Restart Table

File Name	Bit Pos.	File Name	Bit Pos.
BGPDT	94	EED	111
CSTM	94	EQDYN	111
EQEXIN	94	GPLD	111
GPDT	94	SILD	111
GPL	94	TFPOOL	111
SIL	94	USETD	111
ECT	95	LAMA	112
GPTT	96	MI	112
ECPT	97	PHIA	112
EST	97	OEIGS	112
GEI	97	CASEXX	113
GPCT	97	B2PP	114
GPST	98	K2PP	114
KGGX	98	M2PP	114
MGG	99	GMD	115
KGG	100	GOD	115
RG	101	B2DD	115
USET	101	K2DD	115
YS	101	M2DD	115
OGPST	102	BHH	116
GM	103	KHH	116
KNN	104	MHH	116
MNN	104	PHIDH	116
KFF	105	CLAMA	117
KFS	105	OCEIGS	117
MFF	105	PHIH	117
GO	106	OPHIH	118
KAA	106	CPHID	119
KLL	107	CPHIP	120
KLR	107	QPC	120
KRR	107	OCPHIP	121
MLL	107	OEFC1	121
MLR	107	OESC1	121
MRR	107	OQPC1	121
LLL	108	ELSETS	122
ULL	108	GPSETS	122
DM	109	PLTPAR	122
MR	110	PLTSETX	122
		MAA	123

3.11.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 89	1234			67890	12
FILE	1234567890	123456 89	1234			67890	12
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	1	3					
CHKPNT	1	3					
TA1	1234567	3					
SAVE	1234567	3					
COND	12345678	34	4				
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4				
SAVE	123 5 78	4	4				
COND	123 5 78	4	4				
CHKPNT	123 5 78	4	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45	4				
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	12					
GP4	1 90	12					
SAVE	1 90	12					
PARAM	1 90	12					
PURGE	1 90	12					
EQUIV	123456789	4	4				
CHKPNT	1234567890	12 4	4				
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
MCE2	123456789	4	4				
CHKPNT	123456789	4	4				
LABEL	123456789	4	4				
EQUIV	1234567890	4	4				
CHKPNT	1234567890	4	4				
COND	1234567890	4	4				
SCE1	1234567890	4	4				
CHKPNT	1234567890	4	4				
LABEL	1234567890	4	4				
EQUIV	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
COND	1234567890	1 4	4				
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
COND	1234567890	12 4	4				
RBMG1	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
RBMG2	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG3	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG4	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
LABEL	1234567890	12 4	4				
DPD	1 90	12				6 8 0	
SAVE	1 90	12				6 8 0	
COND	1 90	12				6 8 0	
EQUIV	1234567890	12 4	234			6789	
CHKPNT	1 90	12				6 8	
READ	1234567890	12 4	4			89	
SAVE	1234567890	12 4	4			89	
CHKPNT	1234567890	12 4	4			89	
OFP	1234567890	12 4	4			89	
SAVE	1234567890	12 4	4			89	
COND	1234567890	12 4	4			89	
PARAM			23				
PARAM	1234567890	1234 6	23			67890	12
JUMP			23				
$SS	1 3						
LABEL	1234567890	123456 89	123			67890	12
$SS	1 3						
PURGE			23				
CASE	1234567890	1234 6 9	123 5			67890	12
SAVE	1234567890	1234 6 9	123 5			67890	12
CHKPNT	1234567890	1234 6 9	123 5			67890	12
MTRXIN	1		23			67	
SAVE	1		23			67	
PURGE	1234567890	1	23			67	
EQUIV	1234567890	1	23			67	
CHKPNT	1234567890	1	23			67	
GKAD	1234567890	1 4	234			67	
CHKPNT	1234567890	1 4	234			67	
GKAM	1234567890	12 4	234			6789	2
SAVE	1234567890	12 4	234			6789	2

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
CHKPNT	1234567890	12 4	234			6789	2
READ	1234567890	12 4	234			67890	12
SAVE	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
OFP	1234567890	12 4	234			67890	12
SAVE	1234567890	12 4	234			67890	12
COND		9	1				
VDR		9	1				
SAVE		9	1				
COND			1				
OFP			1				
SAVE			1				
LABEL			1				
COND	1234567890	12 4	234			67890	12
DDR1	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
SDR1	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
SDR2		9					
OFP		9					
SAVE		9					
LABEL	1234567890	12				67890	12
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
JUMP	1234567890	123456 89	1234			67890	12
LABEL			23				
$SS	1 3						
PRTPARM			23				
$SS	1 3						
LABEL	1234567890	123456 89	1234			67890	12
PRTPARM	1234567890	123456 89	1234			67890	12
LABEL	1234567890	123456 89	1234			67890	12
PRTPARM	1234567890	123456 89	1234			67890	12
LABEL	1234567890	123456 89	1234			67890	12
PRTPARM	1234567890	123456 89	1234			67890	12
LABEL	1234567890	123456 89	1234			67890	12
END	1234567890	123456 89	1234			67890	12

3.11.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 — 70 — 80
BEGIN	345678901 34
FILE	345678901 34
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1	
SAVE	
COND	
PURGE	
CHKPNT	
SMA1	
CHKPNT	
SMA2	3 678
SAVE	3 678
COND	3 678
CHKPNT	3 678
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	

DMAP Inst.	Bit Position 63 — 70 — 80
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
SMP2	
CHKPNT	
LABEL	
COND	
RBMG1	
CHKPNT	
RBMG2	
CHKPNT	
RBMG3	
CHKPNT	
RBMG4	
CHKPNT	
LABEL	
DPD	
SAVE	
COND	345678901 34
EQUIV	
CHKPNT	
READ	
SAVE	
CHKPNT	
OFP	
SAVE	
COND	345678901 34
PARAM	
PARAM	345678901 34
JUMP	345678901 34
LABEL	345678901 34
PURGE	
CASE	345678901 34
SAVE	345678901 34
CHKPNT	345678901 34
MTRXIN	
SAVE	
PURGE	
EQUIV	
CHKPNT	
GKAD	
CHKPNT	
GKAM	
SAVE	
CHKPNT	
CEAD	

MODAL COMPLEX EIGENVALUE ANALYSIS

DMAP Inst.	Bit Position 63 70 80
SAVE	
CHKPNT	
OFP	
SAVE	
COND	
VDR	
SAVE	
COND	
OFP	
SAVE	
LABEL	
COND	
DDR1	
CHKPNT	
SDR1	345678901 34
CHKPNT	345678901 34
SDR2	
OFP	
SAVE	
LABEL	
COND	345678901 34
REPT	345678901 34
JUMP	345678901 34
JUMP	345678901 34
LABEL	345678901 34
PRTPARM	345678901 34
LABEL	345678901 34
PRTPARM	345678901 34
LABEL	345678901 34
PRTPARM	345678901 34
LABEL	345678901 34
PRTPARM	345678901 34
LABEL	345678901 34
END	345678901 34

3.11.3.5 File Name Restart Table

DMAP Inst.	Bit Position 94	100	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
CHKPNT	4			
GP2	5			
CHKPNT	5			
PLTSET				2
SAVE				2
PRTMSG				2
SETVAL				2
SAVE				2
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				2
GP3	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
COND	7			
PURGE	7	2		
CHKPNT	7			
SMA1	8			
CHKPNT	8			
SMA2	9			
SAVE	9			
COND	9			
CHKPNT	9			
COND				
GPWG				
OFP				
SAVE				
LABEL				
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
PARAM		1		
PURGE		1 3 567 9	0 5	0
EQUIV		4		
CHKPNT				
COND		2		
GPSP		2		
OFP		2		
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		3
CHKPNT		6		3
COND		6		3
SMP1		6		
CHKPNT		6		
SMP2				3
CHKPNT				3
LABEL		6		3
COND		789	0	
RBMG1		7		
CHKPNT		7		
RBMG2		8		
CHKPNT		8		
RBMG3		9		
CHKPNT		9		
RBMG4			0	
CHKPNT			0	
LABEL		789	0	
DPD			1	
SAVE			1	
COND			1	
EQUIV			5	
CHKPNT			1	
READ			2	
SAVE			2	
CHKPNT			2	
OFP			2	
SAVE			2	
COND				
PARAM				
PARAM			3	
JUMP			3	
LABEL			3	
PURGE				
CASE			3	
SAVE			3	
CHKPNT			3	
MTRXIN			4	
SAVE			4	
PURGE			4	
EQUIV			4	
CHKPNT			4	
GKAD			5	
CHKPNT			5	
GKAM			6	
SAVE			6	
CHKPNT			6	
GEAD			7	

DMAP Inst.	94	Bit Position 100	110	120
SAVE			7	
CHKPNT			7	
OFP			7	
SAVE			7	
COND			8	
VDR			8	
SAVE			8	
COND			8	
OFP			8	
SAVE			8	
LABEL			8	
COND			9	
DDR1			9	
CHKPNT			9	
SDR1				0
CHKPNT				0
SDR2				1
OFP				1
SAVE				1
LABEL				
COND				
REPT				
JUMP				
JUMP				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.11.4 Automatic Output for Modal Complex Eigenvalue Analysis

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

The Complex Eigenvalue Summary Table and the Complex Eigenvalue Analysis Summary, as described under Direct Complex Eigenvalue Analysis, are automatically printed for each set of direct input matrices.

3.11.5 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Complex Eigenvalue Analysis:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Complex Eigenvalue Analysis. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Complex Eigenvalue Analysis:

MODAL COMPLEX EIGENVALUE ANALYSIS

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

3.12 MODAL FREQUENCY AND RANDOM RESPONSE

3.12.1 DMAP Sequence for Modal Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

   N A S T R A N  S O U R C E  P R O G R A M  C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.11 MODAL FREQUENCY RESPONSE ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE/ GOD=SAVE/ GMD=SAVE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

  9  SAVE      NSIL,JUMPPLOT $

 10  PRTMSG    PLTSETX// $

 11  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 12  SAVE      PLTFLG,PFILE $

 13  COND      P1,JUMPPLOT $

 14  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 15  SAVE      PFILE $

 16  PRTMSG    PLOTX1// $

 17  LABEL     P1 $

 18  CHKPNT    PLTPAR,GPSETS,ELSETS $

 19  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 20  CHKPNT    GPTT $

 21  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 22  SAVE      NOGENL,NOSIMP,GENEL $

 23  COND      ERROR1,NOSIMP $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  PURGE     OGPST/GENEL $

 25  CHKPNT    EST,ECPT,GPCT,GEI,OGPST $

 26  SMA1      CSTM,MPT,ECPT,GPCT, DIT/KGGX,,GPST/V,N,NOGENL /V,N,NOK4GG $

 27  CHKPNT    KGGX,GPST $

 28  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
               V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
               Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
               CPTRBSC $

 29  SAVE      NOMGG $

 30  COND      ERROR1,NOMGG $

 31  CHKPNT    MGG $

 32  COND      LGPWG,GRDPNT $

 33  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 34  OFP       OGPWG,,,,,//V,N,CARDNO $

 35  SAVE      CARDNO $

 36  LABEL     LGPWG $

 37  EQUIV     KGGX,KGG/NOGENL $

 38  CHKPNT    KGG $

 39  COND      LBL11,NOGENL $

 40  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 41  CHKPNT    KGG $

 42  LABEL     LBL11 $

 43  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 44  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1/ V,
               N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
               V,N,NOSET/V,N,NOL/V,N,NOA $

 45  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

 46  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 47  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF/SINGLE/QPC/NOSR/KLR,KRR,MLR,
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                MPR,DM,MR/REACT/MDD/MODACC $

 48  EQUIV      KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 49  CHKPNT     KPP,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PSF,QPC,USET,KNN,MNN,GOD,
                GMD $

 50  COND       LBL4,GENEL $

 51  GPSP       GPL,GPST,USET,SIL/OGPST $

 52  OFP        OGPST,,,,,//V,N,CARDNO $

 53  SAVE       CARDNO $

 54  LABEL      LBL4 $

 55  COND       LBL2,MPCF1 $

 56  MCE1       USET,RG/GM $

 57  CHKPNT     GM $

 58  MCE2       USET,GM,KGG,MGG,,/KNN,MNN,, $

 59  CHKPNT     KNN,MNN $

 60  LABEL      LBL2 $

 61  EQUIV      KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 62  CHKPNT     KFF,MFF $

 63  COND       LBL3,SINGLE $

 64  SCE1       USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 65  CHKPNT     KFS,KFF,MFF $

 66  LABEL      LBL3 $

 67  EQUIV      KFF,KAA/OMIT/ MFF,MAA/OMIT $

 68  CHKPNT     KAA,MAA $

 69  COND       LBL5,OMIT $

 70  SMP1       USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 71  CHKPNT     GO,KAA $

 72  SMP2       USET,GO,MFF/MAA $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  CHKPNT    MAA $

 74  LABEL     LBL5 $

 75  EQUIV     KAA,KLL/REACT $

 76  CHKPNT    KLL $

 77  COND      LBL6,REACT $

 78  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 79  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

 80  JUMP      LBL8 $

 81  LABEL     LBL6 $

 82  COND      LBL7,MODACC $

 83  LABEL     LBL8 $

 84  RBMG2     KLL/LLL,ULL $

 85  CHKPNT    ULL,LLL $

 86  COND      LBL7,REACT $

 87  RBMG3     LLL,ULL,KLR,KRR/DM $

 88  CHKPNT    DM $

 89  RBMG4     DM,MLL,MLR,MRR/MR $

 90  CHKPNT    MR $

 91  LABEL     LBL7 $

 92  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,
               EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
               V,N,NOFRL/V,N,NONLFT/V,N,TRL/V,N,NOEED/C,N,123/V,N,NOUE $

 93  SAVE      LUSETD,NOUE,NODLT,NOFRL,NOEED,NOPSDL $

 94  COND      ERROR2,NOEED $

 95  PURGE     UEVF/NOUE $

 96  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $

 97  CHKPNT    USETD,EQDYN,TFPOOL,DLT,FRL,EED,GOD,GMD,UEVF,SILD,PSDL,GPLD $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

```
    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 98  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
               NEIGV $

 99  SAVE      NEIGV $

100  CHKPNT    LAMA,PHIA,MI,OEIGS $

101  OFP       OEIGS,LAMA,,,,//V,N,CARDNO $

102  SAVE      CARDNO $

103  COND      ERROR4,NEIGV $

104  PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

105  PARAM     //C,N,MPY/V,N,REPEATF/C,N,1/C,N,-1 $

106  JUMP      LBL13 $
                                                    Top of DMAP Loop
107  LABEL     LBL13 $

108  PURGE     OUAVC1,OUHVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
               OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,   K2PP,M2PP,
               B2PP,K2DD,M2DD,B2DD/NEVER $

109  CASE      CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

110  SAVE      REPEATF,NOLOOP $

111  CHKPNT    CASEXX $

112  MTRXIN    CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
               NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

113  SAVE      NOK2PP,NOM2PP,NOB2PP $

114  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

115  PARAM     //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

116  EQUIV     M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

117  CHKPNT    K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

118  GKAD      USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,    GOD,K2DD,M2DD,
               B2DD/C,N,FREQRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
               V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/    V,N,MPCF1/V,N,SINGLE/V,N,
               OMIT/V,N,NOUE/C,N,-1/C,N,-1/    C,N,+1/V,Y,MODACC = -1 $

119  CHKPNT    MDD,GMD,GOD,K2DD,M2DD,B2DD $

120  GKAM      USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX / MHH,BHH,KHH,
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

```
     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
                PHIDH/V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,  HFREQ=0.0/V,N,
                NCM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/  V,N,FMODE $

121  SAVE       NONCUP,FMODE $

122  CHKPNT     MHH,BHH,KHH,PHIDH $

123  COND       ERROR5,NOFRL $

124  COND       ERROR6,NODLT $

125  FRRD       CASEXX,USETD,DLT,FRL,GMD,GOD,KHH,BHH,MHH,PHIDH,DIT/UHVF,PSF,
                PDF,PPF/C,N,DISP/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,
                OMIT/V,N,NONCUP/V,N,FRQSET/C,Y,DECOMOPT=1 $

126  SAVE       FRQSET $

127  EQUIV      PPF,PDF/NOSET $

128  CHKPNT     PSF,PPF,UHVF,PDF $

129  VDR        CASEXX,EQDYN,USETD,UHVF,PPF,XYCDB,/OUHVC1,/C,N,FREQRESP/C,N,
                MODAL/V,N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

130  SAVE       NOH,NOP,NOSORT2 $

131  COND       LBL16,NOH $

132  COND       LBL16A,NOSORT2 $

133  CHKPNT     OUHVC1 $

134  SDR3       OUHVC1,,,,,/OUHVC2,,,,, $

135  OFP        OUHVC2,,,,,//V,N,CARDNO $

136  SAVE       CARDNO $

137  CHKPNT     OUHVC2 $

138  XYTRAN     XYCDB,OUHVC2,,,,/XYPLTFA/C,N,FREQ/C,N,HSET/V,N,PFILE/V,N,
                CARDNO $

139  SAVE       PFILE,CARDNO $

140  XYPLOT     XYPLTFA // $

141  JUMP       LBL16 $

142  LABEL      LBL16A $

143  OFP        OUHVC1,,,,,//V,N,CARDNO $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

144   SAVE      CARDNO $

145   LABEL     LBL16 $

146   COND      LBL14,NOP $

147   PARAM     //C,N,NOT/V,N,NOMOD/V,Y,MODACC $

148   DDR1      UHVF,PHIDH/UDV1F $

149   CHKPNT    UDV1F $

150   COND      LBLMOD,MODACC $

151   DDR2      USETD,UDV1F,PDF,K2DD,B2DD,MDD,PPF,ULL,LLL,DM/UDV2F,UEVF,PAF/
                C,N,FREQRESP/V,N,NOUE/V,N,REACT/V,N,FRQSET $

152   CHKPNT    UDV2F,UEVF,PAF $

153   EQUIV     UDV2F,UDV1F/NOMOD $

154   CHKPNT    UDV1F $

155   LABEL     LBLMOD $

156   SDR1      USETD,,UDV1F,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

157   CHKPNT    UPVC,QPC $

158   SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,QPC,UPVC,EST,XYCDB/OPPC1,
                OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQ/V,N,NOSORT2 $

159   SAVE      NOSORT2 $

160   COND      LBL18,NOSORT2 $

161   SDR3      OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
                OEFC2, $

162   CHKPNT    OUPVC2,OPPC2,OQPC2,OESC2,OEFC2 $

163   OFP       OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

164   SAVE      CARDNO $

165   XYTRAN    XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
                V,N,PFILE/V,N,CARDNO $

166   SAVE      PFILE,CARDNO $

167   XYPLOT    XYPLTF// $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

168  COND      LBL14,NOPSDL $

169  RANDOM    XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
               V,N,NORD $

170  SAVE      NORD $

171  CHKPNT    PSDF,AUTO $

172  COND      LBL14,NORD $

173  XYTRAN    XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/    V,N,
               CARDNO $

174  SAVE      PFILE,CARDNO $

175  XYPLOT    XYPLTR// $

176  JUMP      LBL14 $

177  LABEL     LBL18 $

178  OFP       OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $

179  SAVE      CARDNO $

180  LABEL     LBL14 $

181  COND      FINIS,REPEATF $

182  REPT      LBL13,100 $
------------------------------------------------- Bottom of DMAP Loop
183  JUMP      ERROR3 $

184  JUMP      FINIS $

185  LABEL     ERROR3 $

186  PRTPARM   //C,N,-3/C,N,MDLERRD $

187  LABEL     ERROR2 $

188  PRTPARM   //C,N,-2/C,N,MDLERRD $

189  LABEL     ERROR1 $

190  PRTPARM   //C,N,-1/C,N,MDLERRD $

191  LABEL     ERROR4 $

192  PRTPARM   //C,N,-4/C,N,MDLERRD $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 11

N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

193  LABEL    ERROR5 $

194  PRTPARM  //C,N,-5/C,N,MDLERRD $

195  LABEL    ERROR6 $

196  PRTPARM  //C,N,-6/C,N,MDLERRD $

197  LABEL    FINIS $

198  END      $
```

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

8. PLTSET transforms user input into a form used to drive structure plotter.

10. PRTMSG prints error messages associated with structure plotter.

13. Go to DMAP No. 17 if no undeformed structure plot request.

14. PLØT generates all requested undeformed structure plots.

16. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

19. GP3 generates Grid Point Temperature Table.

21. TA1 generates element tables for use in matrix assembly and stress recovery.

23. Go to DMAP No. 189 and print error message if there are no structural elements.

26. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

28. SMA2 generates mass matrix $[M_{gg}]$.

30. Go to DMAP No. 189 and print error message if no mass matrix exists.

32. Go to DMAP No. 36 if no weight and balance request.

33. GPWG generates weight and balance information.

34. ØFP formats weight and balance information and places it on the system output file for printing.

37. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

39. Go to DMAP No. 42 if no general elements.

40. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

44. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

48. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

50. Go to DMAP No. 54 if general elements present.

51. GPSP determines if possible grid point singularities remain.

52. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

55. Go to DMAP No. 60 if no multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 72 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

72. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

75. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

77. Go to DMAP No. 81 if no free-body supports.

78. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

80. Go to DMAP No. 83.

82. Go to DMAP No. 91 if no request for mode acceleration data recovery.

84. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

86. Go to DMAP No. 91 if no free-body supports.

87. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

89. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

92. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamic Loads Table, Power Spectral Density List, Frequency Response List and Eigenvalue Extraction Data.

94. Go to DMAP No. 187 and print error message if no Eigenvalue Extraction Data.

96. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

98. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D_m \phi_{ro} \\ \hline \phi_{ro} \end{array}\right]$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

101. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

103. Go to DMAP No. 191 and print error message if no eigenvalues found.

106. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

107. Beginning of loop for additional sets of direct input matrices.

109. CASE extracts user requests from CASECC for current loop.

112. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

116. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points introduced for Dynamic analysis.

118. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

120. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Frequency Response.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where m_i = modal masses

$$b_i = m_i\, 2\pi\, f_i\, g(f_i)$$

$$k_i = m_i\, 4\pi^2 f_i^2$$

and direct input matrices may be complex.

123. Go to DMAP No. 193 and print error message if no Frequency Response List.

124. Go to DMAP No. 195 and print error message if no Dynamic Loads Table.

125. FRRD forms the dynamic load vectors $\{P_h\}$ and solves for the displacements using the following equation

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K_{hh}]\{u_h\} = \{P_h\}.$$

127. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

129. VDR prepares displacements, sorted by frequency, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

131. Go to DMAP No. 145 if no output request for solution points.

132. Go to DMAP No. 142 if no output request for solution points sorted by extra point or mode number.

134. SDR3 sorts the solution point displacements by extra point or mode number.

135. ØFP formats the requested solution point displacements sorted by extra point or mode number and places them on the system output file for printing.

138. XYTRAN prepares the input for X-Y plotting of the solution point displacements vs. frequency.

140. XYPLØT prepares requested X-Y plots of the solution point displacements vs. frequency.

141. Go to DMAP No. 145.

143. ØFP formats the requested solution point displacements sorted by frequency and places them on the system output file for printing.

146. Go to DMAP No. 180 if no output request involving dependent degrees of freedom or forces and stresses.

148. DDR1 transforms the solution vector of displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

150. Go to DMAP No. 155 if mode acceleration technique not requested.

151. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

156. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \left\{\begin{matrix} u_d \\ -- \\ u_o \end{matrix}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{matrix} u_f + u_e \\ --- \\ u_s \end{matrix}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{matrix} u_n + u_e \\ --- \\ u_m \end{matrix}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

158. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPPC1, ØUPVC1, ØQPC1) - all sorted by frequency.

160. Go to DMAP No. 177 if no output requests sorted by point number or element number.

161. SDR3 prepares requested output sorted by point number or element number.

163. ØFP formats the requested output sorted by point number or element number and places it on the system output file for printing.

165. XYTRAN prepares the input for requested X-Y plots.

167. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

168. Go to DMAP No. 180 if no Power Spectral Density List.

169. RANDØM calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.

172. Go to DMAP No. 180 if no RANDØM calculations requested.

173. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

175. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.

176. Go to DMAP No. 180 because there are no frequency response output requests sorted by frequency.

178. ØFP formats the frequency response output requests sorted by frequency and places them on the system output file for printing.

181. Go to DMAP No. 197 if no additional sets of direct input matrices need to be processed.

182. Go to DMAP No. 107 if additional sets of direct input matrices need to be processed.

183. Go to DMAP No. 185 and print error message if more than 100 loops.

184. Go to DMAP No. 197 and make normal exit.

186. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

188. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

190. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

192. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

194. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

196. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

3.12.3 Restart Tables for Modal Frequency and Random Response

3.12.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CSHEAR	2	TEMPMX$	8
ADUM2	1	CTETRA	2	AXISYM$	9
ADUM3	1	CTORDRG	2	MPC	9
ADUM4	1	CTRAPRG	2	MPCADD	9
ADUM5	1	CTRBSC	2	MPCAX	9
ADUM6	1	CTRIA1	2	MPC$	9
ADUM7	1	CTRIA2	2	SPC	10
ADUM8	1	CTRIARG	2	SPC1	10
ADUM9	1	CTRMEM	2	SPCADD	10
AXIC	1	CTRPLT	2	SPCAX	10
AXIF	1	CTUBE	2	SPC$	10
CELAS1	1	CTWIST	2	ASET	11
CELAS2	1	CWEDGE	2	ASET1	11
CELAS3	1	PBAR	3	OMIT	11
CELAS4	1	PCONEAX	3	OMIT1	11
CMASS1	1	PDUM1	3	OMITAX	11
CMASS2	1	PDUM2	3	SUPAX	12
CMASS3	1	PDUM3	3	SUPORT	12
CMASS4	1	PDUM4	3	TEMP	13
CORD1C	1	PDUM5	3	TEMPAX	13
CORD1R	1	PDUM6	3	TEMPD	13
CORD1S	1	PDUM7	3	TEMPP1	13
CORD2C	1	PDUM8	3	TEMPP2	13
CORD2R	1	PDUM9	3	TEMPP3	13
CORD2S	1	PQDMEM	3	TEMPRB	13
GRDSET	1	PQDMEM1	3	WTMASS	14
GRID	1	PQDMEM2	3	GRDPNT	15
GRIDB	1	PQDMEM3	3	PLOTEL	16
POINTAX	1	PQDPLT	3	PLOT$	18
RINGAX	1	PQUAD1	3	POUT$	19
RINGFL	1	PQUAD2	3	XYOUT$	20
SECTAX	1	PROD	3	AOUT$	21
SEQGP	1	PSHEAR	3	LOOP$	22
SPOINT	1	PTORDRG	3	LOOP1$	23
BAROR	2	PTRBSC	3	COUPMASS	24
CBAR	2	PTRIA1	3	CPBAR	24
CCONEAX	2	PTRIA2	3	CPQDPLT	24
CDUM1	2	PTRMEM	3	CPQUAD1	24
CDUM2	2	PTRPLT	3	CPQUAD2	24
CDUM3	2	PTUBE	3	CPROD	24
CDUM4	2	PTWIST	3	CPTRBSC	24
CDUM5	2	GENEL	4	CPTRIA1	24
CDUM6	2	CONM1	5	CPTRIA2	24
CDUM7	2	CONM2	5	CPTRPLT	24
CDUM8	2	PELAS	6	CPTUBE	24
CDUM9	2	PMASS	7	NOLOOP$	25
CHEXA1	2	MAT1	8	RANDOM$	26
CHEXA2	2	MAT2	8	AXYOUT$	27
CONROD	2	MAT3	8	MODACC	53
CQDMEM	2	MATT1	8	TABRND1	54
CQDMEM1	2	MATT2	8	TABRND2	54
CQDMEM2	2	MATT3	8	TABRND3	54
CQDMEM3	2	TABLEM1	8	TABRND4	54
CQDPLT	2	TABLEM2	8	RANDPS	55
CQUAD1	2	TABLEM3	8	RANDT1	55
CQUAD2	2	TABLEM4	8	RANDT2	55
CROD	2	TEMPMT$	8	EPOINT	56

MODAL FREQUENCY AND RANDOM RESPONSE

Card Name	Bit Pos.
SEQEP	56
TF	56
DMIAX	57
DMIG	57
B2PP$	57
K2PP$	57
M2PP$	57
TF$	57
DAREA	58
DELAY	58
DLOAD	58
DPHASE	58
FREQ	58
FREQ1	58
FREQ2	58
RLOAD1	58
RLOAD2	58
TABLED1	58
TABLED2	58
TABLED3	58
TABLED4	58
EIGR	59
METHOD$	60
DECOMOPT	61
DLOAD$	61
FREQ$	61
HFREQ	62
LFREQ	62
LMODES	62
TABDMP1	62
SDAMP$	62

3.12.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
BGPDT	94
CSTM	94
EQEXIN	94
GPDT	94
GPL	94
SIL	94
ECT	95
GPTT	96
ECPT	97
EST	97
GEI	97
GPCT	97
GPST	98
KGGX	98
MGG	99
KGG	100
RG	101
USET	101
YS	101
OGPST	102
GM	103
KNN	104
MNN	104
KFF	105
KFS	105
MFF	105
GO	106
KAA	106
KLL	107
KLR	107
KRR	107
MLL	107
MLR	107
MRR	107
LLL	108
ULL	108
DM	109
MR	110
DLT	111
EED	111
EQDYN	111
FRL	111
GPLD	111
PSDL	111
SILD	111
TFPOOL	111
USETD	111
LAMA	112
MI	112
OEIGS	112
PHIA	112
CASEXX	113
B2PP	114
K2PP	114
M2PP	114
B2DD	115
GMD	115
GOD	115
K2DD	115
M2DD	115
MDD	115
BHH	116
KHH	116
MHH	116
PHIDH	116
PDF	117
PPF	117
PSF	117
UHVF	117
OUHVC1	118
OUHVC2	119
PAF	120
UDV2F	120
UEVF	120
QPC	121
UPVC	121
OEFC1	122
OESC1	122
OPPC1	122
OQPC1	122
OUPVC1	122
OEFC2	123
OESC2	123
OPPC2	123
OQPC2	123
OUPVC2	123
UDV1F	124
AUTO	125
PSDF	125
ELSETS	126
GPSETS	126
PLTPAR	126
PLTSETX	126
MAA	127

3.12.3.3 Card Name Restart Table

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	1234567890	123456 890	1234			34567890	12
FILE	1234567890	123456 890	1234			34567890	12
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12 45	6					
CHKPNT	12 45	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	1	3					
CHKPNT	1	3					
TA1,	1234567	3					
SAVE	1234567	3					
COND	12345678	34	4				
PURGE	1234567	3					
CHKPNT	1234567	3					
SMA1	123 6 8						
CHKPNT	123 6 8						
SMA2	123 5 78	4	4				
SAVE	123 5 78	4	4				
COND	123 5 78	4	4				
CHKPNT	123 5 78	4	4				
COND	123 5 78	45	4				
GPWG	123 5 78	45	4				
OFP	123 5 78	45	4				
SAVE	123 5 78	45	4				
LABEL	123 5 78	45	4				
EQUIV	1234 6 8						
CHKPNT	1234 6 8						
COND	1234 6 8						
SMA3	1234 6 8						
CHKPNT	1234 6 8						
LABEL	1234 6 8						
PARAM	1 90	12					
GP4	1 90	12					
SAVE	1 90	12					
PARAM	1 90	12					
PURGE	1 90	12					
EQUIV	123456789	4	4				
CHKPNT	1234567890	12 4	4				
COND	123 6 890						
GPSP	123 6 890						
OFP	123 6 890						
SAVE	123 6 890						
LABEL	123 6 890						
COND	123456789	4	4				
MCE1	1 9						
CHKPNT	1 9						

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
MCE2	123456789	4	4				
CHKPNT	123456789	4	4				
LABEL	123456789	4	4				
EQUIV	1234567890	4	4				
CHKPNT	1234567890	4	4				
COND	1234567890	4	4				
SCE1	1234567890	4	4				
CHKPNT	1234567890	4	4				
LABEL	1234567890	4	4				
EQUIV	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
COND	1234567890	1 4	4				
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
EQUIV	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
COND	1234567890	12 4	4				
RBMG1	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
JUMP	1234 6 890	12					
LABEL	1234 6 890	12					
COND	1234 6 890	12					
LABEL	1234 6 890	12					
RBMG2	1234 6 890	12					
CHKPNT	1234 6 890	12					
COND	1234 6 890	12					
RBMG3	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG4	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
LABEL	1234567890	12 4	4				
DPD	1 90	12				56 89	
SAVE	1 90	12				56 89	
COND	1 90	12				56 89	
PURGE	1 90	12				56 89	
EQUIV	1234567890	12 4	234			67 90	
CHKPNT	1 90	12				56 89	
READ	1234567890	12 4	4			90	
SAVE	1234567890	12 4	4			90	
CHKPNT	1234567890	12 4	4			90	
OFP	1234567890	12 4	4			90	
SAVE	1234567890	12 4	4			90	
COND	1234567890	12 4	4			90	
PARAM			23				
PARAM	1234567890	1234 6	23			34567890	12
JUMP			23				
$SS	1 3						
LABEL	1234567890	123456 890	123			34567890	12
$SS	1 3						
PURGE			23				
CASE	1234567890	1234 6 9	123 5			34567890	12
SAVE	1234567890	1234 6 9	123 5			34567890	12
CHKPNT	1234567890	1234 6 9	123 5			34567890	12
MTRXIN	1		23			67	

MODAL FREQUENCY AND RANDOM RESPONSE

DMAP Inst.	Bit Position 1 … 10	20	30	40	50	60	
SAVE	1		23			67	
PURGE	1234567890	1	23			67	
PARAM	1234567890	1	23			67	
EQUIV	1234567890	1	23			67	
CHKPNT	1234567890	1	23			67	
GKAD	1234567890	1 4	234			3 67 0	
CHKPNT	1234567890	1 4	234			3 67 0	
GKAM	1234567890	12 4	234			67 90	2
SAVE	1234567890	12 4	234			67 90	2
CHKPNT	1234567890	12 4	234			67 90	2
COND	1234567890	12 4	234			67890	12
COND	1234567890	12 4	234			67890	12
FRRD	1234567890	12 4	234			67890	12
SAVE	1234567890	12 4	234			67890	12
EQUIV	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
VDR		90	1 7				
SAVE		90	1 7				
COND			1 7				
COND			1 7				
CHKPNT			1 7				
SDR3			1 7				
OFP			1				
SAVE			1				
CHKPNT			1 7				
XYTRAN			7				
SAVE			7				
XYPLOT			7				
JUMP			7				
LABEL			7				
OFP			1				
SAVE			1				
LABEL		0	7				
COND	1234567890	12 4	234			3 67890	12
PARAM	1234567890	12 4	234			3 67890	12
DDR1	1234567890	12 4	234			3 67890	12
CHKPNT	1234567890	12 4	234			3 67890	12
COND	1234567890	12 4	234			3 67890	12
$SS	23						
DDR2	1234567890	12 4	234			3 67890	12
$SS	23						
CHKPNT	1234567890	12 4	234			3 67890	12
$SS	23						
EQUIV	1234567890	12 4	234			3 67890	12
$SS	23						
CHKPNT	1234567890	12 4	234			3 67890	12
$SS	23						
LABEL	1234567890	12 4	234			3 67890	12
$SS	23						
SDR1	1234567890	12 4	234			3 67890	12
CHKPNT	1234567890	12 4	234			3 67890	12
SDR2		90					
SAVE		90					
COND		90					
SDR3		90					
CHKPNT		90					
OFP		9					

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
SAVE		9					
XYTRAN		0					
SAVE		0					
XYPLOT		0					
COND		0	6			45	
RANDOM			6			45	
SAVE			6			45	
CHKPNT			6			45	
COND			6			45	
XYTRAN		0					
SAVE		0					
XYPLOT		0					
JUMP		0					
LABEL		9					
OFP		9					
SAVE		9					
LABEL		0				45	
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
JUMP	1234567890	123456 890	1234			34567890	12
LABEL			23				
$SS	1 3						
PRTPARM			23				
$SS	1 3						
LABEL	1234567890	123456 890	1234			34567890	12
PRTPARM	1234567890	123456 890	1234			34567890	12
LABEL	1234567890	123456 890	1234			34567890	12
PRTPARM	1234567890	123456 890	1234			34567890	12
LABEL	1234567890	123456 890	1234			34567890	12
PRTPARM	1234567890	123456 890	1234			34567890	12
LABEL	1234567890	123456 890	1234			34567890	12
PRTPARM	1234567890	123456 890	1234			34567890	12
LABEL	1234567890	123456 890	1234			34567890	12
PRTPARM	1234567890	123456 890	1234			34567890	12
LABEL	1234567890	123456 890	1234			34567890	12
END	1234567890	123456 890	1234			34567890	12

3.12.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 70 80
BEGIN	3456789012 4
FILE	3456789012 4
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
COND	
PURGE	
CHKPNT	
SMA1	
CHKPNT	
SMA2	3 678
SAVE	3 678
COND	3 678
CHKPNT	3 678
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	

DMAP Inst.	Bit Position 63 70 80
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
SMP2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
RBMG1	
CHKPNT	
JUMP	
LABEL	
COND	
LABEL	
RBMG2	
CHKPNT	
COND	
RBMG3	
CHKPNT	
RBMG4	
CHKPNT	
LABEL	
DPD	
SAVE	
COND	3456789012 4
PURGE	
EQUIV	
CHKPNT	
READ	
SAVE	
CHKPNT	
OFP	
SAVE	
COND	3456789012 4
PARAM	
PARAM	3456789012 4
JUMP	3456789012 4
LABEL	3456789012 4
PURGE	
CASE	3456789012 4
SAVE	3456789012 4
CHKPNT	3456789012 4
MTRXIN	
SAVE	
PURGE	

DMAP Inst.	Bit Position 63 70 80
PARAM	
EQUIV	
CHKPNT	
GKAD	
CHKPNT	
GKAM	
SAVE	
CHKPNT	
COND	3456789012 4
COND	3456789012 4
FRRD	
SAVE	
EQUIV	
CHKPNT	
VDR	
SAVE	
COND	
COND	
CHKPNT	
SDR3	
OFP	
SAVE	
CHKPNT	
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	
OFP	
SAVE	
LABEL	
COND	
PARAM	
DDR1	
CHKPNT	
COND	
DDR2	
CHKPNT	
EQUIV	
CHKPNT	
LABEL	
SDR1	3456789012 4
CHKPNT	3456789012 4
SDR2	
SAVE	
COND	
SDR3	
CHKPNT	
OFP	
SAVE	
XYTRAN	
SAVE	
XYPLOT	
COND	3456789012 4
RANDOM	3456789012 4
SAVE	3456789012 4
CHKPNT	3456789012 4

DMAP Inst.	Bit Position 63 70 80
COND	
XYTRAN	
SAVE	
XYPLOT	
JUMP	
LABEL	
OFP	
SAVE	
LABEL	
COND	3456789012 4
REPT	3456789012 4
JUMP	3456789012 4
JUMP	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
PRTPARM	3456789012 4
LABEL	3456789012 4
END	3456789012 4

3.12.3.5 File Name Restart Table

```
DMAP                   Bit Position
Inst.      94    100       110       120

BEGIN
FILE
GP1         4
SAVE        4
CHKPNT      4
GP2          5
CHKPNT       5
PLTSET                                  6
SAVE                                    6
PRTMSG                                  6
SETVAL                                  6
SAVE                                    6
COND
PLOT
SAVE
PRTMSG
LABEL
CHKPNT                                  6
GP3           6
CHKPNT        6
TA1,           7
SAVE           7
COND           7
PURGE          7    2
CHKPNT         7
SMA1            8
CHKPNT          8
SMA2             9
SAVE             9
COND             9
CHKPNT           9
COND
GPWG
OFP
SAVE
LABEL
EQUIV             0
CHKPNT            0
COND              0
SMA3              0
CHKPNT            0
LABEL             0
PARAM              1
GP4                1
SAVE               1
PARAM              1
PURGE              1 3 567 90    5     1
EQUIV                 4
CHKPNT
COND                2
GPSP                2
OFP                 2
SAVE                2
LABEL               2
COND                 34
MCE1                 3
CHKPNT               3
```

DMAP Inst.	64	Bit Position 100	110	120
MCE2		4		
CHKPNT		4		
LABEL		34		
EQUIV		5		
CHKPNT		5		
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		7
CHKPNT		6		7
COND		6		7
SMP1		6		
CHKPNT		6		
SMP2				7
CHKPNT				7
LABEL		6		7
EQUIV		7		
CHKPNT		7		
COND		7		
RBMG1		7		
CHKPNT		7		
JUMP				
LABEL		7		
COND		890		
LABEL		8		
RBMG2		8		
CHKPNT		8		
COND		9		
RBMG3		9		
CHKPNT		9		
RBMG4			0	
CHKPNT			0	
LABEL		890		
DPD			1	
SAVE			1	
COND			1	
PURGE			1	
EQUIV			5	
CHKPNT			1	
READ			2	
SAVE			2	
CHKPNT			2	
OFP			2	
SAVE			2	
COND			2	
PARAM				
PARAM			3	
JUMP			3	
LABEL			3	
PURGE				
CASE			3	
SAVE			3	
CHKPNT			3	
MTRXIN			4	
SAVE			4	
PURGE			4	

DMAP	Bit Position			
Inst.	64	100	110	120
PARAM			4	
EQUIV			4	
CHKPNT			4	
GKAD			5	
CHKPNT			5	
GKAM			6	
SAVE			6	
CHKPNT			6	
COND			7	
COND			7	
FRRD			7	
SAVE			7	
EQUIV			7	
CHKPNT			7	
VDR			8	
SAVE			8	
COND			8	
COND			8	
CHKPNT			8	
SDR3			9	
OFP				
SAVE				
CHKPNT			9	
XYTRAN				
SAVE				
XYPLOT				
JUMP				
LABEL				
OFP				
SAVE				
LABEL				
COND				0 4
PARAM				
DDR1				4
CHKPNT				4
COND				0
DDR2				0
CHKPNT				0
EQUIV				0
CHKPNT				0
LABEL				0
SDR1				1
CHKPNT				1
SDR2				2
SAVE				2
COND				3
SDR3				3
CHKPNT				3
OFP				
SAVE				
XYTRAN				
SAVE				
XYPLOT				
COND				5
RANDOM				5
SAVE				5
CHKPNT				5

DMAP Inst.	64	Bit Position 100	110	120
COND				
XYTRAN				
SAVE				
XYPLOT				
JUMP				
LABEL				
OFP				
SAVE				
LABEL				
COND				
REPT				
JUMP				
JUMP				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.12.4 Automatic Output for Modal Frequency and Random Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.12.5 Case Control Deck and Parameters for Modal Frequency and Random Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Frequency and Random Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.

2. All of the eigenvectors used in the modal formulation must be determined in a single execution.

3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Frequency and Random Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Frequency and Random Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

7. DECØMØPT - optional for frequency response problems. The integer value of this parameter is used to control the type of arithmetic used in the decomposition of the dynamic equations. A value of 1 (default) means that double precision, complex arithmetic with partial pivoting will be used. A value of 2 means that double precision, complex arithmetic without pivoting will be used. A value of 4 means that single precision, complex arithmetic without pivoting will be used.

3.13 MODAL TRANSIENT RESPONSE

3.13.1 DMAP Sequence for Modal Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

     N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     NO.12 MODAL TRANSIENT RESPONSE ANALYSIS - SERIES M1 $

  2  FILE      LLL=TAPE $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  C,N,
               123/V,N,NOGPDT $

* 4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT $

  9  SAVE      NSIL,JUMPPLOT $

 10  PRTMSG    PLTSETX// $

 11  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFILE/C,N,0 $

 12  SAVE      PLTFLG,PFILE $

 13  COND      P1,JUMPPLOT $

 14  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,/PLOTX1/ V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 15  SAVE      JUMPPLOT,PLTFLG,PFILE $

 16  PRTMSG    PLOTX1// $

 17  LABEL     P1 $

 18  CHKPNT    PLTPAR,GPSETS,ELSETS $

 19  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/C,N,123/V,N,NOGRAV/C,N,123 $

 20  CHKPNT    GPTT $

 21  TA1,      ,ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,,GEI,ECPT,GPCT/V,N,LUSET/ C,N,
               123/V,N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

 22  SAVE      NOGENL,NOSIMP,GENEL $

 23  COND      ERROR1,NOSIMP $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  PURGE     OGPST/GENEL $

 25  CHKPNT    EST,ECPT,GPCT,GEI,OGPST $

 26  SMA1      CSTM,MPT,ECPT,GPCT, DIT/KGGX,,GPST/V,N,NOGENL /V,N,NOK4GG $

 27  CHKPNT    KGGX,GPST $

 28  SMA2      CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/C,N,-1/
               V,Y,COUPMASS/V,Y,CPBAR/V,Y,CPROD/V,Y,CPQUAD1/V,Y,CPQUAD2/   V,
               Y,CPTRIA1/V,Y,CPTRIA2/V,Y,CPTUBE/V,Y,CPQDPLT/V,Y,CPTRPLT/ V,Y,
               CPTRBSC $

 29  SAVE      NOMGG $

 30  COND      ERROR1,NOMGG $

 31  CHKPNT    MGG $

 32  COND      LGPWG,GRDPNT $

 33  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $

 34  OFP       OGPWG,,,,,//V,N,CARDNO $

 35  SAVE      CARDNO $

 36  LABEL     LGPWG $

 37  EQUIV     KGGX,KGG/NOGENL $

 38  CHKPNT    KGG $

 39  COND      LBL11,NOGENL $

 40  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

 41  CHKPNT    KGG $

 42  LABEL     LBL11 $

 43  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

 44  GP4       CASECC,GEOM4,EQEXIN,SIL,GPDT/RG,,USET,/V,N,LUSET/V,N,MPCF1/ V,
               N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,N,REPEAT/
               V,N,NOSET/V,N,NOL/V,N,NOA $

 45  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

 46  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

 47  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST/SINGLE/QP/NOSR/KLR,KRR,MLR,MR,
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.
                 MPR,DM/REACT $

 48  EQUIV       KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

 49  CHKPNT      KRR,KLR,DM,MLR,MPR,MR,GM,RG,GO,KFS,PST,QP,USET,KNN,MNN,GOD,
                 GMD $

 50  COND        LBL4,GENEL $

 51  GPSP        GPL,GPST,USET,SIL/OGPST $

 52  OFP         OGPST,,,,,//V,N,CARDNO $

 53  SAVE        CARDNO $

 54  LABEL       LBL4 $

 55  COND        LBL2,MPCF1 $

 56  MCE1        USET,RG/GM $

 57  CHKPNT      GM $

 58  MCE2        USET,GM,KGG,MGG,,/KNN,MNN,, $

 59  CHKPNT      KNN,MNN $

 60  LABEL       LBL2 $

 61  EQUIV       KNN,KFF/SINGLE/MNN,MFF/SINGLE $

 62  CHKPNT      KFF,MFF $

 63  COND        LBL3,SINGLE $

 64  SCE1        USET,KNN,MNN,,/KFF,KFS,,MFF,, $

 65  CHKPNT      KFS,KFF,MFF $

 66  LABEL       LBL3 $

 67  EQUIV       KFF,KAA/OMIT/ MFF,MAA/OMIT $

 68  CHKPNT      KAA,MAA $

 69  COND        LBL5,OMIT $

 70  SMP1        USET,KFF,,,/GO,KAA,KOO,LOO,UOO,,,,, $

 71  CHKPNT      GO,KAA $

 72  SMP2        USET,GO,MFF/MAA $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 73  CHKPNT   MAA $

 74  LABEL    LBL5 $

 75  EQUIV    KAA,KLL/REACT $

 76  CHKPNT   KLL $

 77  COND     LBL6,REACT $

 78  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

 79  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

 80  JUMP     LBL8 $

 81  LABEL    LBL6 $

 82  COND     LBL7,MODACC $

 83  LABEL    LBL8 $

 84  RBMG2    KLL/LLL,ULL $

 85  CHKPNT   ULL,LLL $

 86  COND     LBL7,REACT $

 87  RBMG3    LLL,ULL,KLR,KRR/DM $

 88  CHKPNT   DM $

 89  RBMG4    DM,MLL,MLR,MRR/MR $

 90  CHKPNT   MR $

 91  LABEL    LBL7 $

 92  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,
              EED ,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

 93  SAVE     LUSETD,NODLT,NONLFT,NOTRL,NOUE,NOEED $

 94  COND     ERROR2,NOEED $

 95  PURGE    UEVT/NOUE/PNLH/NONLFT $

 96  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

 97  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,EED,GOD,GMD,UEVT,NLFT,PNLH,SILD,
              GPLD $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

    N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 98  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

 99  SAVE     NEIGV $

100  CHKPNT   LAMA,PHIA,MI,OEIGS $

101  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

102  SAVE     CARDNO $

103  COND     ERROR4,NEIGV $

104  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

105  SAVE     NOK2PP,NOM2PP,NOB2PP $

106  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

107  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

108  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

109  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

110  GKAD     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,   GOD,K2DD,M2DD,
              B2DD/C,N,TRANRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
              V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/V,N,NOUE/C,N,-1/C,N,-1/   C,N,+1/V,Y,MODACC = -1 $

111  CHKPNT   MDD,GMD,GOD,K2DD,M2DD,B2DD $

112  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/  MHH,BHH,KHH,
              PHIDH/V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/  C,Y,HFREQ=0.0/V,N,
              NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/  V,N,FMODE $

113  SAVE     NONCUP,FMODE $

114  CHKPNT   MHH,BHH,KHH,PHIDH $

115  COND     ERROR5,NOTRL $

116  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

117  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

118  JUMP     LBL13 $
                                                           Top of DMAP Loop
119  LABEL    LBL13 $

120  PURGE    PNLH,OUHV1,OPNL1,OUHV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
                OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT/NEVER $

121  CASE       CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $

122  SAVE       REPEATT,NOLOOP $

123  CHKPNT     CASEXX $

124  TRD        CASEXX,USETD,DLT,TRL,NLFT,DIT,KHH,BHH,MHH,GMD,GOD,PHIDH/UHVT,
                PDT,PST,PPT,PNLH/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/ V,
                N,OMIT/V,N,NONCUP/V,N,NOUE/C,N,0 $

125  CHKPNT     UHVT,PDT,PST,PPT,PNLH $

126  VDR        CASEXX,EQDYN,USETD,UHVT,PPT,XYCDB,PNLH/OUHV1,OPNL1/ C,N,
                TRANRESP/C,N,MODAL/C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE $

127  SAVE       NOH,NOP $

128  CHKPNT     OUHV1,OPNL1 $

129  COND       LBL16,NOH $

130  SDR3       OUHV1,OPNL1,,,,/OUHV2,OPNL2,,,, $

131  OFP        OUHV2,OPNL2,,,,//V,N,CARDNO $

132  SAVE       CARDNO $

133  CHKPNT     OPNL2,OUHV2 $

134  XYTRAN     XYCDB,OUHV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,HSET/V,N,PFILE/V,N,
                CARDNO $

135  SAVE       PFILE,CARDNO $

136  XYPLOT     XYPLTTA// $

137  LABEL      LBL16 $

138  PARAM      //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

139  COND       LBL15,PJUMP $

140  PARAM      //C,N,NOT/V,N,NOMOD/V,Y,MODACC $

141  DDR1       UHVT,PHIDH/UDV1T $

142  CHKPNT     UDV1T $

143  COND       LBLMOD,MODACC $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.

144  DDR2     USETD,UDV1T,PDT,K2DD,B2DD,MDD,,ULL,LLL,DM/UDV2T,UEVT,PAF/  C,N,
              TRANRESP/V,N,NOUE/V,N,REACT/C,N,0 $

145  CHKPNT   UDV2T,UEVT,PAF $

146  EQUIV    UDV2T,UDV1T/NOMOD $

147  CHKPNT   UDV1T $

148  LABEL    LBLMOD $

149  EQUIV    UDV1T,UPV/NOA $

150  COND     LBL14,NOA $

151  SDR1     USETD,,UDV1T,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $

152  LABEL    LBL14 $

153  CHKPNT   UPV,QP $

154  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,PPT,QP,UPV,EST,XYCDB/
              OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $

155  SDR3     OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $

156  CHKPNT   OPP2,OQP2,OUPV2,OES2,OEF2 $

157  OFP      OUPV2,OPP2,OQP2,OEF2,OES2,//V,N,CARDNO $

158  SAVE     CARDNO $

159  COND     P2,JUMPPLOT $

160  PLOT     PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV/PLOTX2/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

161  SAVE     PFILE $

162  PRTMSG   PLOTX2// $

163  LABEL    P2 $

164  XYTRAN   XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $

165  SAVE     PFILE,CARDNO $

166  XYPLOT   XYPLTT// $

167  LABEL    LBL15 $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 12

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

168   COND      FINIS,REPEATT $

169   REPT      LBL13,100 $
------------------------------------------------------   Bottom of DMAP Loop
170   JUMP      ERROR3 $

171   JUMP      FINIS $

172   LABEL     ERROR3 $

173   PRTPARM   //C,N,-3/C,N,MDLTRD $

174   LABEL     ERROR2 $

175   PRTPARM   //C,N,-2/C,N,MDLTRD $

176   LABEL     ERROR1 $

177   PRTPARM   //C,N,-1/C,N,MDLTRD $

178   LABEL     ERROR4 $

179   PRTPARM   //C,N,-4/C,N,MDLTRD $

180   LABEL     ERROR5 $

181   PRTPARM   //C,N,-5/C,N,MDLTRD $

182   LABEL     FINIS $

183   END       $
```

3.13.2 Description of DMAP Operations for Modal Transient Response.

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

8. PLTSET transforms user input into a form used to drive structure plotter.

10. PRTMSG prints error messages associated with structure plotter.

13. Go to DMAP No. 17 if no undeformed structure plot request.

14. PLØT generates all requested undeformed structure plots.

16. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

19. GP3 generates Grid Point Temperature Table.

21. TA1 generates element tables for use in matrix assembly and stress recovery.

23. Go to DMAP No. 176 and print error message if there are no structural elements.

26. SMA1 generates stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

28. SMA2 generates mass matrix $[M_{gg}]$.

30. Go to DMAP No. 176 and print error message if no mass matrix exists.

32. Go to DMAP No. 36 if no weight and balance request.

33. GPWG generates weight and balance information.

34. ØFP formats weight and balance information and places it on the system output file for printing.

37. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

39. Go to DMAP No. 42 if no general elements.

40. SMA3 adds general elements to stiffness matrix $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

44. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

48. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

50. Go to DMAP No. 54 if general elements present.

51. GPSP determines if possible grid point singularities remain.

52. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

55. Go to DMAP No. 60 if no multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m]$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints:

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 74 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

72. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

75. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if free-body supports.

77. Go to DMAP No. 81 if no free-body supports.

78. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

80. Go to DMAP No. 83.

82. Go to DMAP No. 91 if no request for mode acceleration data recovery.

84. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

86. Go to DMAP No. 91 if no free-body supports.

87. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

89. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

92. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Eigenvalue Extraction Data, Dynamic Loads Table, Nonlinear Function Table and Transient Response List.

94. Go to DMAP No. 174 and print error message if no Eigenvalue Extraction Data.

96. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

98. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

101. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

103. Go to DMAP No. 178 and print error message if no eigenvalues found.

104. MTRXIN selects the direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$.

108. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied. Equivalence $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points.

110. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

112. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Transient Response.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i\, 2\pi\, f_i\, g(f_i)$$

$$k_i = m_i\, 4\pi^2 f_i^2$$

and all matrices are real.

115. Go to DMAP No. 180 and print error message if no Transient Response List.

118. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

119. Beginning of loop for additional dynamic load sets.

121. CASE extracts user requests from CASECC for current loop.

124. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P^{n\ell}_d\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = \{P_h\} + \{P^{n\ell}_h\}$$

126. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

129. Go to DMAP No. 137 if no output request for the solution points.

130. SDR3 sorts the solution point displacements, velocities, accelerations and nonlinear load vectors by point number.

131. ØFP formats the requested solution point displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.

134. XYTRAN prepares the input for X-Y plotting of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

135. XYPLØT prepares requested X-Y plots of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

139. Go to DMAP No. 167 if no output request involving dependent degrees of freedom, forces and stresses, or deformed structure plot.

141. DDR1 transforms the solution vector displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

143. Go to DMAP No. 148 if mode acceleration technique not requested.

144. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

149. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

150. Go to DMAP No. 152 if no constraints applied.

151. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \ , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

154. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output (OPP1, OUPV1, PUGV, OQP1) - all sorted by time step.

155. SDR3 prepares requested output sorted by point number or element number.

157. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.

159. Go to DMAP No. 163 if no deformed structure plots requested.

160. PLØT prepares all requested deformed structure plots.

162. PRTMSG prints plotter data nad engineering data for each deformed plot generated.

164. XYTRAN prepares the input for requested X-Y plots.

166. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.

168. Go to DMAP No. 182 if no additional dynamic load sets need to be processed.

169. Go to DMAP No. 118 if additional dynamic load sets need to be processed.

170. Go to DMAP No. 172 and print error message if more than 100 loops.

171. Go to DMAP No. 182 and make normal exit.

173. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

175. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

177. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

179. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULA-TIØN.

181. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANS-IENT RESPØNSE CALCULATIØNS.

3.13.3 Restart Tables for Modal Transient Response

3.13.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.	Card Name	Bit Pos.	Card Name	Bit Pos.
ADUM1	1	CSHEAR	2	TEMPMX$	8
ADUM2	1	CTETRA	2	AXISYM$	9
ADUM3	1	CTORDRG	2	MPC	9
ADUM4	1	CTRAPRG	2	MPCADD	9
ADUM5	1	CTRBSC	2	MPCAX	9
ADUM6	1	CTRIA1	2	MPC$	9
ADUM7	1	CTRIA2	2	SPC	10
ADUM8	1	CTRIARG	2	SPC1	10
ADUM9	1	CTRMEM	2	SPCADD	10
AXIC	1	CTRPLT	2	SPCAX	10
AXIF	1	CTUBE	2	SPC$	10
CELAS1	1	CTWIST	2	ASET	11
CELAS2	1	CWEDGE	2	ASET1	11
CELAS3	1	PBAR	3	OMIT	11
CELAS4	1	PCONEAX	3	OMIT1	11
CMASS1	1	PDUM1	3	OMITAX	11
CMASS2	1	PDUM2	3	SUPAX	12
CMASS3	1	PDUM3	3	SUPORT	12
CMASS4	1	PDUM4	3	TEMP	13
CORD1C	1	PDUM5	3	TEMPAX	13
CORD1R	1	PDUM6	3	TEMPD	13
CORD1S	1	PDUM7	3	TEMPP1	13
CORD2C	1	PDUM8	3	TEMPP2	13
CORD2R	1	PDUM9	3	TEMPP3	13
CORD2S	1	PQDMEM	3	TEMPRB	13
GRDSET	1	PQDMEM1	3	WTMASS	14
GRID	1	PQDMEM2	3	GRDPNT	15
GRIDB	1	PQDMEM3	3	PLOTEL	16
POINTAX	1	PQDPLT	3	PLOT$	18
RINGAX	1	PQUAD1	3	POUT$	19
RINGFL	1	PQUAD2	3	XYOUT$	20
SECTAX	1	PROD	3	AOUT$	21
SEQGP	1	PSHEAR	3	LOOP$	22
SPOINT	1	PTORDRG	3	LOOP1$	23
BAROR	2	PTRBSC	3	COUPMASS	24
CBAR	2	PTRIA1	3	CPBAR	24
CCONEAX	2	PTRIA2	3	CPQDPLT	24
CDUM1	2	PTRMEM	3	CPQUAD1	24
CDUM2	2	PTRPLT	3	CPQUAD2	24
CDUM3	2	PTUBE	3	CPROD	24
CDUM4	2	PTWIST	3	CPTRBSC	24
CDUM5	2	GENEL	4	CPTRIA1	24
CDUM6	2	CONM1	5	CPTRIA2	24
CDUM7	2	CONM2	5	CPTRPLT	24
CDUM8	2	PELAS	6	CPTUBE	24
CDUM9	2	PMASS	7	NOLOOP$	25
CHEXA1	2	MAT1	8	AXYOUT$	27
CHEXA2	2	MAT2	8	MODACC	55
CONROD	2	MAT3	8	EPOINT	56
CQDMEM	2	MATT1	8	SEQEP	56
CQDMEM1	2	MATT2	8	TF	56
CQDMEM2	2	MATT3	8	DMIAX	57
CQDMEM3	2	TABLEM1	8	DMIG	57
CQDPLT	2	TABLEM2	8	B2PP$	57
CQUAD1	2	TABLEM3	8	K2PP$	57
CQUAD2	2	TABLEM4	8	M2PP$	57
CROD	2	TEMPMT$	8	TF$	57

Card Name	Bit Pos.
DAREA	58
DELAY	58
DLOAD	58
NOLIN1	58
NOLIN2	58
NOLIN3	58
NOLIN4	58
TABLED1	58
TABLED2	58
TABLED3	58
TABLED4	58
TLOAD1	58
TLOAD2	58
TSTEP	58
EIGR	59
METHOD$	60
DLOAD$	61
NLFORCE	61
TSTEP$	61
HFREQ	62
LFREQ	62
LMODES	62
TABDMP1	62
SDAMP$	62

3.13.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.	File Name	Bit Pos.
BGPDT	94	K2DD	114
CSTM	94	M2DD	114
EQEXIN	94	MDD	114
GPDT	94	BHH	115
GPL	94	KHH	115
SIL	94	MHH	115
ECT	95	PHIDH	115
GPTT	96	CASEXX	116
ECPT	97	PDT	117
EST	97	PNLH	117
GEI	97	PPT	117
GPCT	97	PST	117
GPST	98	UHVT	117
KGGX	98	OPNL1	118
MGG	99	OUHV1	118
KGG	100	OPNL2	119
RG	101	OUHV2	119
USET	101	PAF	120
YS	101	UDV2T	120
OGPST	102	UEVT	120
GM	103	QP	121
KNN	104	UPV	121
MNN	104	OEF1	122
KFF	105	OES1	122
KFS	105	OPP1	122
MFF	105	OQP1	122
GO	106	OUPV1	122
KAA	106	PUGV	122
KLL	107	OEF2	123
KLR	107	OES2	123
KRR	107	OPP2	123
MLL	107	OQP2	123
MLR	107	OUPV2	123
MRR	107	UDV1T	124
LLL	108	ELSETS	125
ULL	108	GPSETS	125
DM	109	PLTPAR	125
MR	110	PLTSETX	125
DLT	111	MAA	126
EED	111		
EQDYN	111		
GPLD	111		
NLFT	111		
SILD	111		
TFPOOL	111		
TRL	111		
USETD	111		
LAMA	112		
MI	112		
OEIGS	112		
PHIA	112		
B2PP	113		
K2PP	113		
M2PP	113		
B2DD	114		
GMD	114		
GOD	114		

3.13.3.3 Card Name Restart Table

```
DMAP                                     Bit Position
Inst.    1        10        20        30        40        50        60

BEGIN    1234567890123456 8901234                              56789012
FILE     1234567890123456 8901234                              56789012
GP1      1
SAVE     1
CHKPNT   1
GP2      12 45          6
CHKPNT   12 45          6
PLTSET                    8
SAVE                      8
PRTMSG                    8
SETVAL                    8
SAVE                      8
COND                      8
PLOT                      8
SAVE                      8
PRTMSG                    8
LABEL                     8
CHKPNT                    8
GP3      1           3
CHKPNT   1           3
TAI,     1234567     3
SAVE     1234567     3
COND     12345678    34         4
PURGE    1234567     3
CHKPNT   1234567     3
SMA1     123  6 8
CHKPNT   123  6 8
SMA2     123 5 78     4         4
SAVE     123 5 78     4         4
COND     123 5 78     4         4
CHKPNT   123 5 78     4         4
COND     123 5 78     45        4
GPWG     123 5 78     45        4
OFP      123 5 78     45        4
SAVE     123 5 78     45        4
LABEL    123 5 78     45        4
EQUIV    1234   8
CHKPNT   1234 6 8
COND     1234 6 8
SMA3     1234 6 8
CHKPNT   1234 6 8
LABEL    1234 6 8
PARAM    1       9012
GP4      1       9012
SAVE     1       9012
PARAM    1       9012
PURGE    1       9012
EQUIV    123456789    4         4
CHKPNT   123456789012 4         4
COND     123  6 890
GPSP     123  6 890
OFP      123  6 890
SAVE     123  6 890
LABEL    123  6 890
COND     123456789    4         4
MCE1     1       9
CHKPNT   1       9
```

DMAP Inst.	Bit Position 1–10	11–20	21–30	31–40	41–50	51–60	61–
MCE2	123456789	4	4				
CHKPNT	123456789	4	4				
LABEL	123456789	4	4				
EQUIV	1234567890	4	4				
CHKPNT	1234567890	4	4				
COND	1234567890	4	4				
SCE1	1234567890	4	4				
CHKPNT	1234567890	4	4				
LABEL	1234567890	4	4				
EQUIV	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
COND	1234567890	1 4	4				
SMP1	1234 6 890	1					
CHKPNT	1234 6 890	1					
SMP2	1234567890	1 4	4				
CHKPNT	1234567890	1 4	4				
LABEL	1234567890	1 4	4				
EQUIV	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
COND	1234567890	12 4	4				
RBMG1	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
JUMP	1234 6 890	12					
LABEL	1234 6 890	12					
COND	1234 6 890	12					
LABEL	1234 6 890	12					
RBMG2	1234 6 890	12					
CHKPNT	1234 6 890	12					
COND	1234 6 890	12					
RBMG3	1234 6 890	12					
CHKPNT	1234 6 890	12					
RBMG4	1234567890	12 4	4				
CHKPNT	1234567890	12 4	4				
LABEL	1234567890	12 4	4				
DPD	1 90	12				6 89	
SAVE	1 90	12				6 89	
COND	1 90	12				6 89	
PURGE	1 90	12				6 89	
EQUIV	1234567890	12 4	4			67 90	
CHKPNT	1 90	12				6 89	
READ	1234567890	12 4	4			0	
SAVE	1234567890	12 4	4			0	
CHKPNT	1234567890	12 4	4			0	
OFP	1234567890	12 4	4			0	
SAVE	1234567890	12 4	4			0	
COND	1234567890	12 4	4			0	
MTRXIN	1					67	
SAVE	1					67	
PURGE	1234567890	1				67	
PARAM	1234567890	1				67	
EQUIV	1234567890	1				67	
CHKPNT	1234567890	1				67	
GKAD	1234567890	1 4	4			67 0	
CHKPNT	1234567890	1 4	4			67 0	
GKAM	1234567890	12 4	4			67 90	2
SAVE	1234567890	12 4	4			67 90	2
CHKPNT	1234567890	12 4	4			67 90	2

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
COND	1234567890	12 4	4			67 90	2
PARAM			23				
PARAM	1234567890	1234 6	234			567890	12
JUMP		4	234				
$SS	1 3						
LABEL	1234567890	123456 890	1234			567890	12
$SS	1 3						
PURGE			23				
CASE	1234567890	1234 6 9	12345			567890	12
SAVE	1234567890	1234 6 9	12345			567890	12
CHKPNT	1234567890	1234 6 9	12345			567890	12
TRD	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
VDR		90	1 7				
SAVE		90	1 7				
CHKPNT			1 7				
COND			1 7				
SDR3			1 7				
OFP			1				
SAVE			1				
CHKPNT			1				
XYTRAN			7				
SAVE			7				
XYPLOT			7				
LABEL			1				
PARAM	1234567890	12 4	234			567890	12
COND	1234567890	12 4	234			567890	12
PARAM	1234567890	12 4	234			567890	12
DDR1	1234567890	12 4	234			67890	12
CHKPNT	1234567890	12 4	234			67890	12
COND	1234567890	12 4	234			567890	12
$SS	23						
DDR2	1234567890	12 4	234			567890	12
$SS	23						
CHKPNT	1234567890	12 4	234			567890	12
$SS	23						
EQUIV	1234567890	12 4	234			567890	12
$SS	23						
CHKPNT	1234567890	12 4	234			567890	12
$SS	23						
LABEL	1234567890	12 4	234			567890	12
$SS	23						
EQUIV	1234567890	12 4	234			567890	12
COND	1234567890	12 4	234			567890	12
SDR1	1234567890	12 4	234			567890	12
LABEL	1234567890	12 4	234			567890	12
CHKPNT	1234567890	12 4	234			567890	12
SDR2		890					
SDR3		890					
CHKPNT		890					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					

DMAP Inst.	Bit Position 1	10	20	30	40	50	60
XYTRAN		0					
SAVE		0					
XYPLOT		0					
LABEL		0					
COND			23				
$SS	1 3						
REPT			23				
$SS	1 3						
JUMP			23				
$SS	1 3						
JUMP	1234567890	123456 890	1234			567890	12
LABEL			23				
$SS	1 3						
PRTPARM			23				
$SS	1 3						
LABEL	1234567890	123456 890	1234			567890	12
PRTPARM	1234567890	123456 890	1234			567890	12
LABEL	1234567890	123456 890	1234			567890	12
PRTPARM	1234567890	123456 890	1234			567890	12
LABEL	1234567890	123456 890	1234			567890	12
PRTPARM	1234567890	123456 890	1234			567890	12
LABEL	1234567890	123456 890	1234			567890	12
PRTPARM	1234567890	123456 890	1234			567890	12
LABEL	1234567890	123456 890	1234			567890	12
END	1234567890	123456 890	1234			567890	12

3.13.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position 63 — 70 — 80
BEGIN	34567890123
FILE	34567890123
GP1	
SAVE	
CHKPNT	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
COND	
PURGE	
CHKPNT	
SMA1	
CHKPNT	
SMA2	3 678
SAVE	3 678
COND	3 678
CHKPNT	3 678
COND	
GPWG	
OFP	
SAVE	
LABEL	
EQUIV	
CHKPNT	
COND	
SMA3	
CHKPNT	
LABEL	
PARAM	
GP4	
SAVE	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	

DMAP Inst.	Bit Position 63 — 70 — 80
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
SMP2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
RBMG1	
CHKPNT	
JUMP	
LABEL	
COND	
LABEL	
RBMG2	
CHKPNT	
COND	
RBMG3	
CHKPNT	
RBMG4	
CHKPNT	
LABEL	
DPD	
SAVE	
COND	34567890123
PURGE	
EQUIV	
CHKPNT	
READ	
SAVE	
CHKPNT	
OFP	
SAVE	
COND	34567890123
MTRXIN	
SAVE	
PURGE	
PARAM	
EQUIV	
CHKPNT	
GKAD	
CHKPNT	
GKAM	
SAVE	
CHKPNT	

DMAP Inst.	Bit Position 63 70 80
COND	34567890123
PARAM	
PARAM	34567890123
JUMP	34567890123
LABEL	34567890123
PURGE	
CASE	34567890123
SAVE	34567890123
CHKPNT	34567890123
TRD	
CHKPNT	
VDR	
SAVE	
CHKPNT	
COND	
SDR3	
OFP	
SAVE	
CHKPNT	
XYTRAN	
SAVE	
XYPLOT	
LABEL	
PARAM	
COND	
PARAM	
DDR1	
CHKPNT	
COND	
DDR2	
CHKPNT	
EQUIV	
CHKPNT	
LABEL	
EQUIV	
COND	34567890123
SDR1	34567890123
LABEL	34567890123
CHKPNT	34567890123
SDR2	
SDR3	
CHKPNT	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
XYTRAN	
SAVE	
XYPLOT	
LABEL	
COND	34567890123
REPT	34567890123
JUMP	34567890123
JUMP	34567890123

DMAP Inst.	Bit Position 63 70 80
LABEL	34567890123
PRTPARM	34567890123
LABEL	34567890123
PRTPARM	34567890123
LABEL	34567890123
PRTPARM	34567890123
LABEL	34567890123
PRTPARM	34567890123
LABEL	34567890123
PRTPARM	34567890123
LABEL	34567890123
END	34567890123

3.13.3.5 File Name Restart Table

DMAP Inst.	Bit Position 94	100	110	120
BEGIN				
FILE				
GP1	4			
SAVE	4			
CHKPNT	4			
GP2	5			
CHKPNT	5			
PLTSET				5
SAVE				5
PRTMSG				5
SETVAL				5
SAVE				5
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
CHKPNT				5
GP3	6			
CHKPNT	6			
TA1,	7			
SAVE	7			
COND	7			
PURGE	7	2		
CHKPNT	7			
SMA1	8			
CHKPNT	8			
SMA2	9			
SAVE	9			
COND	9			
CHKPNT	9			
COND				
GPWG				
OFP				
SAVE				
LABEL				
EQUIV		0		
CHKPNT		0		
COND		0		
SMA3		0		
CHKPNT		0		
LABEL		0		
PARAM		1		
GP4		1		
SAVE		1		
PARAM		1		
PURGE		1 3 567 9	0 4	1
EQUIV		4		
CHKPNT				
COND		2		
GPSP		2		
OFP		2		
SAVE		2		
LABEL		2		
COND		34		
MCE1		3		
CHKPNT		3		

DMAP Inst.	64	Bit Position 100 — 110	120
MCE2		4	
CHKPNT		4	
LABEL		34	
EQUIV		5	
CHKPNT		5	
COND		5	
SCE1		5	
CHKPNT		5	
LABEL		5	
EQUIV		6	6
CHKPNT		6	6
COND		6	6
SMP1		6	
CHKPNT		6	
SMP2			6
CHKPNT			6
LABEL		6	6
EQUIV		7	
CHKPNT		7	
COND		7	
RBMG1		7	
CHKPNT		7	
JUMP			
LABEL		7	
COND		890	
LABEL		8	
RBMG2		8	
CHKPNT		8	
COND		9	
RBMG3		9	
CHKPNT		9	
RBMG4		0	
CHKPNT		0	
LABEL		890	
DPD		1	
SAVE		1	
COND		1	
PURGE		1	
EQUIV		4	
CHKPNT		1	
READ		2	
SAVE		2	
CHKPNT		2	
OFP		2	
SAVE		2	
COND		2	
MTRXIN		3	
SAVE		3	
PURGE		3	
PARAM		3	
EQUIV		3	
CHKPNT		3	
GKAD		4	
CHKPNT		4	
GKAM		5	
SAVE		5	
CHKPNT		5	

DMAP Inst.	64	100	110	120
COND			7	
PARAM				
PARAM				
JUMP				
LABEL				
PURGE				
CASE			6	
SAVE			6	
CHKPNT			6	
TRD			7	
CHKPNT			7	
VDR			8	
SAVE			8	
CHKPNT			8	
COND			9	
SDR3			9	
OFP				
SAVE				
CHKPNT			9	
XYTRAN				
SAVE				
XYPLOT				
LABEL			9	
PARAM				0
COND				0
PARAM				
DDR1				4
CHKPNT				4
COND				0
DDR2				0
CHKPNT				0
EQUIV				0
CHKPNT				0
LABEL				0
EQUIV				1
COND				1
SDR1				1
LABEL				1
CHKPNT				1
SDR2				2
SDR3				3
CHKPNT				
OFP				
SAVE				
COND				
PLOT				
SAVE				
PRTMSG				
LABEL				
XYTRAN				
SAVE				
XYPLOT				
LABEL				
COND				
REPT				
JUMP				
JUMP				

DMAP Inst.	64	Bit Position 100	110	120
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.13.4 Automatic Output for Modal Transient Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.13.5 Case Control Deck and Parameters for Modal Transient Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Transient Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Transient Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness (see Section 3.1 for list of elements). See Section 3.1.5 for an explanation of the use of these parameters.

4. LFREQ and HFREQ - required unless LMØDES is used. The values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

3.14 NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.14.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     HEAT NO.03 NON-LINEAR STATIC HEAT TRANSFER ANALYSIS $

  2  GP1       GEOM1,GEOM2,/HGPL,HEQEXIN,HGPDT,HCSTM,HBGPDT,HSIL/V,N,HLUSET/
               C,N,123/V,N,HNOGPDT $

  3  SAVE      HLUSET $

  4  CHKPNT    HGPL,HEQEXIN,HGPDT,HCSTM,HBGPDT,HSIL $

  5  GP2       GEOM2,HEQEXIN/HECT $

  6  CHKPNT    HECT $

  7  PLTSET    PCDB,HEQEXIN,HECT/HPLTSETX,HPLTPAR,HGPSETS,HELSETS/  V,N,HNSIL/
               V,N,JUMPPLOT $

  8  SAVE      HNSIL,JUMPPLOT $

  9  PRTMSG    HPLTSETX//$

 10  SETVAL    //V,N,HPLTFLG/C,N,1/V,N,HPFILE/C,N,0 $

 11  SAVE      HPLTFLG,HPFILE $

 12  COND      HP1,JUMPPLOT $

 13  PLOT      HPLTPAR,HGPSETS,HELSETS,CASECC,HBGPDT,HEQEXIN,HSIL,,/HPLOTX1/
               V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,HPLTFLG/V,N,HPFILE $

 14  SAVE      JUMPPLOT,HPLTFLG,HPFILE $

 15  PRTMSG    HPLOTX1//$

 16  LABEL     HP1 $

 17  CHKPNT    HPLTPAR,HGPSETS,HELSETS $

 18  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,HGPTT/C,N,123/V,N,HNOGRAV/C,N,123 $

 19  CHKPNT    HSLT,HGPTT $

 20  TA1,      ,HECT,EPT,HBGPDT,HSIL,HGPTT,HCSTM/HEST,,HGEI,HECPT,HGPCT/  V,N,
               HLUSET/C,N,123/V,N,HNOSIMP/C,N,0/V,N,HNOGENL/V,N,HXYZ $

 21  SAVE      HNOSIMP,HNOGENL $

 22  COND      HERROR2,HNOSIMP $

 23  CHKPNT    HEST,HECPT,HGPCT $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  SMA1      HCSTM,MPT,HECPT,HGPCT,DIT/HKGGX,,HGPST/V,N,HNOGENL/V,N,HNOK4GG/
               V,N,HNNLK $

 25  SAVE      HNNLK $

 26  CHKPNT    HGPST,HKGGX $

 27  RMG       HEST,MATPCOL,HGPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
               V,N,HNLR/V,N,HLLSET $

 28  SAVE      HNLR $

 29  EQUIV     HKGGX,HKGG/HNLR $

 30  PURGE     HQGE,HRGG/HNLR $

 31  CHKPNT    HKGG,HQGE,HRGG $

 32  GP4       CASECC,GEOM4,HEQEXIN,HSIL,HGPDT/HRG,HYS,HUSET,/V,N,HLLSET/  V,
               N,HMPCF1/V,N,HMPCF2/V,N,HSINGLE/V,N,HOMIT/V,N,HREACT/ V,N,
               HNSKIP/V,N,HREPEAT/V,N,HNOSET/V,N,HNOL/V,N,HNOA $

 33  SAVE      HMPCF1,HMPCF2,HSINGLE,HOMIT,HREACT,HNSKIP,HREPEAT,HNOSET,HNOL,
               HNOA $

 34  COND      HERROR1,HNOL $

 35  PURGE     HGM/HMPCF1/HPS,HKFS,HKSS,HKSF,HRSN,HQG/HSINGLE $

 36  EQUIV     HKGG,HKNN/HMPCF1/HRGG,HRNN/HMPCF1 $

 37  CHKPNT    HGM,HPS,HKFS,HKSS,HUSET,HRG,HKNN,HRNN,HKSF,HRSN,HYS $

 38  GPSP      HGPL,HGPST,HUSET,HSIL/HOGPST $

 39  OFP       HOGPST,,,,,//V,N,HCARDNO $

 40  SAVE      HCARDNO $

 41  COND      HLBL1,HMPCF2 $

 42  MCE1      HUSET,HRG/HGM $

 43  CHKPNT    HGM $

 44  MCE2      HUSET,HGM,HKGG,HRGG,,/HKNN,HRNN,, $

 45  CHKPNT    HKNN,HRNN $

 46  LABEL     HLBL1 $

 47  EQUIV     HKNN,HKFF/HSINGLE/HRNN,HRFN/HSINGLE $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48  CHKPNT    HKFF,HRFN $

 49  COND      HLBL2,HSINGLE $

 50  VEC       HUSET/V/C,N,N/C,N,F/C,N,S $

 51  PARTN     HKNN,V,/HKFF,HKSF,HKFS,HKSS $

 52  PARTN     HRNN,,V/HRFN,HRSN,,/C,N,1 $

 53  LABEL     HLBL2 $

 54  CHKPNT    HKFS,HKSS,HKFF,HKSF,HRFN,HRSN $

 55  DECOMP    HKFF/HLLL,HULL/C,N,0/C,N,0/V,N,HMDIAG/V,N,HDET/V,N,HPWR/V,N,
               HKSING $

 56  SAVE      HKSING $

 57  COND      HERROR3,HKSING $

 58  CHKPNT    HLLL,HULL $

 59  SSG1      HSLT,HBGPDT,HCSTM,HSIL,HEST,MPT,HGPTT,EDT,,CASECC,DIT/ HPG/V,N,
               HLUSET/V,N,HNSKIP $

 60  CHKPNT    HPG $

 61  EQUIV     HPG,HPF/HNOSET $

 62  COND      HLBL3,HNOSET $

 63  SSG2      HUSET,HGM,HYS,HKFS,,,HPG/,,HPS,HPF $

 64  LABEL     HLBL3 $

 65  CHKPNT    HPF,HPS $

 66  SSGHT     HUSET,HSIL,HGPTT,HGM,HEST,MPT,DIT,HPF,HPS,HKFF,HKFS,HKSF, HKSS,
               HRFN,HRSN,HLLL,HULL/HUGV,HQG,HRULV/V,N,HNNLK/V,N,HNLR/ C,Y,
               EPSHT=.001/C,Y,TABS=0.0/C,Y,MAXIT=4/V,Y,HIRES=-1/V,N,   HMPCF1/
               V,N,HSINGLE $

 67  CHKPNT    HUGV,HQG,HRULV $

 68  COND      HLBL4,HIRES $

 69  MATGPR    HGPL,HUSET,HSIL,HRULV//C,N,F $

 70  LABEL     HLBL4 $

 71  PLTTRAN   HBGPDT,HSIL/HBGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 3 HEAT

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 72  SAVE     HLUSEP $

 73  CHKPNT   HBGPDP,HSIP $

 74  SDR2     CASECC,HCSTM,MPT,DIT,HEQEXIN,HSIL,HGPTT,EDT,HBGPDP,HPG,HQG,
              HUGV,HEST,/HOPG1,HOQG1,HOUGV1,HOES1,HOEF1,HPUGV1/C,N,STATICS $

 75  OFP      HOUGV1,HOPG1,HOQG1,,,//V,N,HCARDNO $

 76  SAVE     HCARDNO $

 77  SDRHT    HSIL,HUSET,HUGV,HOEF1,HSLT,HEST,DIT,HQGE,,/HOEF1X/C,Y,TABS/
              V,N,HNLR $

 78  OFP      HOEF1X,,,,,//V,N,HCARDNO $

 79  SAVE     HCARDNO $

 80  COND     HP2,JUMPPLOT $

 81  PLOT     HPLTPAR,HGPSETS,HELSETS,CASECC,HBGPDT,HEQEXIN,HSIP,HPUGV1,/
              HPLOTX2/V,N,HNSIL/V,N,HLUSEP/V,N,JUMPPLOT/V,N,HPLTFLG/V,N,
              HPFILE $

 82  PRTMSG   HPLOTX2// $

 83  LABEL    HP2 $

 84  JUMP     FINIS$

 85  LABEL    HERROR1 $

 86  PRTPARM  //C,N,-1/C,N,HSTATICS $

 87  LABEL    HERROR2 $

 88  PRTPARM  //C,N,-2/C,N,HSTATICS $

 89  LABEL    HERROR3 $

 90  PRTPARM  //C,N,-3/C,N,HSTATICS $

 91  LABEL    FINIS$

 92  END      $
```

3.14.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis

2. GP1 generates grid point location tables and tables relating internal and external degree of freedom numbers.

5. GP2 generates the Element Connection Table.

7. PLTSET transforms the input data into plot data tables.

9. PRTMSG prints error messages associated with the plot data.

13. PLØT generates all plots of the structure without temperature profiles.

15. PRTMSG prints plotter and engineering data for each generated plot.

18. GP3 generates applied heat flux load tables (SLT) and the grid point temperature table.

20. TA1 generates element tables for use in matrix formulation, load generation, and element heat flux data recovery.

24. SMA1 generates the conductivity matrix, $[K^x_{gg}]$, and the grid point singularity table.

27. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element radiation flux matrix, $[Q_{ge}]$, is also generated for use in recovery data for the HBDY elements.

32. GP4 generates flags defining member of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = \{0\}$.

34. Go to DMAP instruction 85 if no independent degrees of freedom are defined.

38. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

39. ØFP prints the singularity messages.

41. Go to DMAP statement 46 if no multi-point constraints exist.

42. MCE1 partitions the multi-point constraint equation matrix $[R_g] = [R_m \vdots R_n]$ and solves for the multi-point constraint transformation matrix

$$[G_m] = -[R_m]^{-1}[R_n].$$

44. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[R_{nn}] = [\bar{R}_{nn}] + [G_m^T][R_{mn}] + [R_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

47. Equivalence $[K_{ff}]$ to $[K_{nn}]$ and $[R_{fn}]$ to $[R_{nn}]$ if no single-point constraints exist.

49. Go to DMAP statement 53 if no single-point constraints exist.

50. VEC is used to generate a partitioning vector $u_n \rightarrow u_f + u_s$.

51. PARTN is used to partition the conductivity matrix

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{fs} & K_{ss} \end{array}\right] .$$

52. PARTN is used to partition the radiation matrix

$$[R_{nn}] = \left[\begin{array}{c} R_{fn} \\ \hdashline R_{sn} \end{array}\right] .$$

55. DECØMP decomposes the potentially unsymmetric matrix K_{ff} into upper and lower triangular factors $[U_{\ell\ell}]$ and $[L_{\ell\ell}]$.

57. Go to DMAP statement 89 if the matrix is singular.

59. SSG1 is used to generate the input heat flux vector $\{P_g\}$.

62. Go to DMAP statement 64 if no constraints of any kind exist.

63. SSG2 reduces the heat flux vector

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hdashline P_m \end{array}\right\} ,$$

$$\{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c} P_f \\ \hdashline P_s \end{array}\right\} .$$

66. SSGHT solves the nonlinear heat transfer problems by iteration. It uses user input parameters EPSHT and MAXIT to limit the iterations. For details, refer to Section 8 of the NASTRAN Theoretical Manual. The output data blocks are: $\{u_g\}$, the solution temperature vector, $\{q_g\}$, the heat flux due to single point constraints, and $\{\delta P_\ell\}$, the matrix of residual heat fluxes at each iteration step.

68. Go to DMAP statement 70 if no residual vectors are desired.

69. MATGPR prints the matrix of residual vectors.

71. PLTTRAN transforms the grid point definition tables into a format for plotting temperature solutions.

74. SDR2 calculates the heat flux due to conductivity and convection in the elements and prepares the solution vectors for output.

75. ØFP formats tables prepared by SDR2 for output.

77. SDRHT processes the HBDY elements to produce heat flux into the elements due to convection, radiation, and user applied flux.

78. ØFP formats the output element flux table for output.

80. Go to DMAP 83 if no temperature profile plots are requested.

81. PLØT generates temperature profile plots.

82. PRTMSG prints plotter data and engineering data for each plot generated.

84. Go to DMAP 92 and make normal exit.

86. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

88. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.

90. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - STIFFNESS MATRIX SINGULAR.

3.14.3 Restart Tables for Nonlinear Static Heat Transfer Analysis

3.14.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
GRDSET	1
GRID	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CHBDY	2
CHEXA1	2
CHEXA2	2
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQUAD1	2
CQUAD2	2
CROD	2
CTETRA	2
CTRAPRG	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTUBE	2
CWEDGE	2
PBAR	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PHBDY	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQUAD1	3
PQUAD2	3
PROD	3
PTRBSC	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTUBE	3
PELAS	6
MAT1	8
MAT2	8
MAT3	8
MAT4	8
MAT5	8
MATT1	8
MATT2	8
MATT3	8
MATT4	8
MATT5	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8
TEMPMX$	8
MPC	9
MPCADD	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
TEMP	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
PLOTEL	16
HIRES	17
PLOT$	18
POUT$	19
EPSHT	54
MAXIT	54
RADMTX	55
RADLST	55
SIGMA	55
TABS	55
SPCD	56
LOAD$	59
LOAD	60
QBDY1	60
QBDY2	60
QHBDY	60
QVECT	60
QVOL	60
SLOAD	60
TEMPLD$	62

3.14.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
HBGPDT	94
HCSTM	94
HEQEXIN	94
HGPDT	94
HGPL	94
HSIL	94
HECT	95
HGPTT	96
HSLT	96
HECPT	97
HEST	97
HGEI	97
HGPCT	97
HGPST	98
HKGGX	98
HRGG	99
HKGG	100
HRG	101
HUSET	101
HYS	101
HOGPST	102
HGM	103
HKNN	104
HRNN	104
HKFF	105
HKFS	105
HKSS	105
HKLL	107
HKLR	107
HKRR	107
HLLL	108
HULL	108
HPG	110
HPL	111
HPS	111
HQR	111
HRULV	112
HULV	112
HPGG	113
HQG	113
HUGV	113
HOEF1	114
HOES1	114
HOPG1	114
HOQG1	114
HOUGV1	114
HPUGV1	114
HELSETS	115
HGPSETS	115
HPLTPAR	115
HPLTSETX	115

3.14.3.3 Card Name Restart Table

Bit Position

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
BEGIN	123 6 890	1 3 6789				90	2
GP1	1						
SAVE	1						
CHKPNT	1						
GP2	12	6					
CHKPNT	12	6					
PLTSET		8					
SAVE		8					
PRTMSG		8					
SETVAL		8					
SAVE		8					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
CHKPNT		8					
GP3	12	3				0	
CHKPNT	12	3				0	
TA1,	123 6	3					
SAVE	123 6	3					
COND	123 6 8	3					
CHKPNT	123 6	3					
SMA1	123 6 8	3					
SAVE	123 6 8	3					
CHKPNT	123 6 8	3					
RMG	123 6 8	3				5	
SAVE	123 6 8	3				5	
EQUIV	123 6 8	3				5	
PURGE	123 6 8	3				5	
CHKPNT	123 6 8	3				5	
GP4	1 90	1				6	
SAVE	1 90	1				6	
COND	1 90	1				6	
PURGE	1 90	1				6	
EQUIV	123 6 89	3				6	
CHKPNT	123 6 89	3				6	
GPSP	123 6 890	3					
OFP	123 6 8 0	3					
SAVE	123 6 8 0	3					
COND	123 6 89	3					
MCE1	1 9						
CHKPNT	1 9						
MCE2	123 6 89	3				5	
CHKPNT	123 6 89	3				5	
LABEL	123 6 89	3				5	
EQUIV	123 6 890	3				5	
CHKPNT	123 6 890	3				5	
COND	123 6 890	3				5	
VEC	123 6 890	3				5	
PARTN	123 6 890	3				5	
PARTN	123 6 890	3				5	
LABEL	123 6 890	3				5	
CHKPNT	123 6 890	3				5	
DECOMP	123 6 890	3				5	
SAVE	123 6 890	3				5	
COND	123 6 890	3				5	

Bit Position

DMAP Inst.	1–10	11–20	21–30	31–40	41–50	51–60	61–
CHKPNT	123 6 890	3				5	
SSG1	123 6 8	3				5 90	2
CHKPNT	123 6 8	3				5 90	2
EQUIV	123 6 890	1 3				5 90	2
COND	123 6 890	1 3				5 90	2
SSG2	123 6 890	1 3				5 90	2
LABEL	123 6 890	1 3				5 90	2
CHKPNT	123 6 890	1 3				56 90	2
SSGHT	123 6 890	1 3				456 90	2
CHKPNT	123 6 890	1 3				456 90	2
COND	123 6 890	1 3				456 90	2
MATGPR	123 6 890	1 3				456 90	2
LABEL	123 6 890	1 3				456 90	2
PLTTRAN	123 6 890	1 3				456	
SAVE	123 6 890	1 3				456	
CHKPNT	123 6 890	1 3				456 90	2
SDR2		89					
OFP		9					
SAVE		9					
SDRHT		89					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
PRTMSG		8					
LABEL		8					
JUMP	123 6 890	1 3 6789				4 6 90	2
LABEL	123 6 890	1 3 6789				4 6 90	2
PRTPARM	123 6 890	1 3 6789				4 6 90	2
LABEL	123 6 890	1 3 6789				4 6 90	2
PRTPARM	123 6 890	1 3 6789				4 6 90	2
LABEL	123 6 890	1 3 6789				4 6 90	2
PRTPARM	123 6 890	1 3 6789				4 6 90	2
LABEL	123 6 890	1 3 6789				4 6 90	2
END	123 6 890	1 3 6789				4 6 90	2

3.14.3.4 Rigid Format Change Restart Table

DMAP Inst.	63	70	80
BEGIN		1	
GP1		1	
SAVE			
CHKPNT			
GP2			
CHKPNT			
PLTSET			
SAVE			
PRTMSG			
SETVAL			
SAVE			
COND			
PLOT			
SAVE			
PRTMSG			
LABEL			
CHKPNT			
GP3			
CHKPNT			
TA1,			
SAVE			
COND		1	
CHKPNT			
SMA1			
SAVE			
CHKPNT			
RMG			
SAVE			
EQUIV			
PURGE			
CHKPNT			
GP4			
SAVE			
COND		1	
PURGE			
EQUIV			
CHKPNT			
GPSP			
OFP			
SAVE			
COND			
MCE1			
CHKPNT			
MCE2			
CHKPNT			
LABEL			
EQUIV			
CHKPNT			
COND			
VEC			
PARTN			
PARTN			
LABEL			
CHKPNT			
DECOMP			
SAVE			
COND			

DMAP Inst.	63	70	80
CHKPNT			
SSG1			
CHKPNT			
EQUIV			
COND			
SSG2			
LABEL			
CHKPNT			
SSGHT			
CHKPNT			
COND		1	
MATGPR		1	
LABEL		1	
PLTTRAN			
SAVE			
CHKPNT			
SDR2			
OFP			
SAVE			
SDRHT			
OFP			
SAVE			
COND			
PLOT			
PRTMSG			
LABEL			
JUMP		1	
LABEL		1	
PRTPARM		1	
LABEL		1	
PRTPARM		1	
LABEL		1	
PRTPARM		1	
LABEL		1	
END			

3.14.3.5 File Name Restart Table

DMAP Inst.	94	95	96	97	98	100	101	102	103	104	105	107	111	115
BEGIN														
GP1	4													
SAVE	4													
CHKPNT	4													
GP2		5												
CHKPNT		5												
PLTSET														5
SAVE														5
PRTMSG														5
SETVAL														5
SAVE														5
COND														
PLOT														
SAVE														
PRTMSG														
LABEL														
CHKPNT														5
GP3			6											
CHKPNT			6											
TA1,				7										
SAVE				7										
COND				7										
CHKPNT				7										
SMA1					8									
SAVE					8									
CHKPNT					8									
RMG						0								
SAVE						0								
EQUIV						0								
PURGE														
CHKPNT						0								
GP4							1							
SAVE							1							
COND							1							
PURGE							1		3		5	7	1	
EQUIV										4				
CHKPNT										4				
GPSP								2						
OFP								2						
SAVE								2						
COND									3	4				
MCE1									3					
CHKPNT									3					
MCE2										4				
CHKPNT										4				
LABEL									3	4				
EQUIV											5			
CHKPNT											5			
COND											5			
VEC														
PARTN														
PARTN														
LABEL														
CHKPNT														
DECOMP					8									
SAVE														
COND														

DMAP Inst.	Bit Position 94	100	110	120
CHKPNT		8		
SSG1			0	
CHKPNT			0	
EQUIV			1	
COND			1	
SSG2			1	
LABEL			1	
CHKPNT			1	
SSGHT				
CHKPNT			2	
COND				
MATGPR				
LABEL				
PLTTRAN				
SAVE				
CHKPNT			3	
SDR2			4	
OFP				
SAVE				
SDRHT				
OFP				
SAVE				
COND				
PLOT				
PRTMSG				
LABEL				
JUMP				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
PRTPARM				
LABEL				
END				

3.14.4 Case Control Deck and Parameters for Nonlinear Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Nonlinear Static Heat Transfer Analysis:

1. A single subcase must be defined with a single loading condition (LØAD) and a single constraint condition (SPC).

2. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP(MATERIAL) request. Temperatures for constrained components are taken from these TEMP cards and entries on SPC cards are ignored.

The following output may be requested for the last iteration in Nonlinear Static Heat Transfer Analysis:

1. Temperature (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.

2. The punch option of a THERMAL request will produce TEMP bulk data cards.

3. Flux density (ELFØRCE) in selected elements. In the case of CHBDY elements, a flux density summary is produced that includes applied flux, radiation flux, and convective flux.

4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Nonlinear Static Heat Transfer Analysis:

1. <u>MAXIT</u> - optional - the integer value of this parameter limits the maximum number of iterations.

2. <u>PSHT</u> - optional - the real value of this parameter is used to test the convergence of the solution.

3. <u>TABS</u> - optional - the real value of this parameter is the absolute reference temperature.

4. <u>SIGMA</u> - optional - the real value of this parameter is the Stefan-Boltzmann constant.

5. <u>HIRES</u> - optional - a positive value of this parameter will cause the printing of the residual vectors following the execution of SSGHT for each iteration.

3.15 TRANSIENT HEAT TRANSFER ANALYSIS

3.15.1 DMAP Sequence for Transient Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

  1  BEGIN     HEAT NO.9 TRANSIENT HEAT TRANSFER ANALYSIS $

  2  FILE      KGGX=TAPE/ KGG=TAPE $

  3  GP1       GEOM1,GEOM2,/HGPL,HEQEXIN,HGPDT,HCSTM,HBGPDT,HSIL/V,N,HLUSET/
               V,N,HALWAYS=-1/V,N,HNOGPDT $

  4  SAVE      HLUSET,HNOGPDT$

  5  PURGE     HUSET,HGM,HGO,HKAA,HBAA,HPSO,HKFS,HQP,HEST/HNOGPDT $

  6  CHKPNT    HGPL,HEQEXIN,HGPDT,HCSTM,HBGPDT,HSIL,HUSET,HGM,HGO,HKAA,HBAA,
               HPSO,HKFS,HQP,HEST $

  7  COND      HLBL5,HNOGPDT$

  8  GP2       GEOM2,HEQEXIN/HECT $

  9  CHKPNT    HECT $

 10  PLTSET    PCDB,HEQEXIN,HECT/HPLTSETX,HPLTPAR,HGPSETS,HELSETS/V,N,HNSIL/V,
               N,JUMPPLOT $

 11  SAVE      HNSIL,JUMPPLOT $

 12  PRTMSG    HPLTSETX//$

 13  SETVAL    //V,N,HPLTFLG/C,N,1/V,N,HPFILE/C,N,0 $

 14  SAVE      HPLTFLG,HPFILE $

 15  COND      HP1,JUMPPLOT$

 16  PLOT      HPLTPAR,HGPSETS,HELSETS,CASECC,HBGPDT,HEQEXIN,HSIL,,/HPLOTX1/
               V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,HPLTFLG/V,N,HPFILE $

 17  SAVE      JUMPPLOT,HPLTFLG,HPFILE $

 18  PRTMSG    HPLOTX1//$

 19  LABEL     HP1 $

 20  CHKPNT    HPLTPAR,HGPSETS,HELSETS $

 21  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,HGPTT/C,N,123/C,N,123/C,N,123 $

 22  CHKPNT    HGPTT,HSLT $

 23  TA1,      ,HECT,EPT,HBGPDT,HSIL,HGPTT,HCSTM/HEST,,HGEI,HECPT,HGPCT/  V,N,
               HLUSET/C,N,123/V,N,HNOSIMP=-1/C,N,0/C,N,123/C,N,123 $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 24  SAVE      HNOSIMP $

 25  CHKPNT    HEST,HECPT,HGPCT $

 26  COND      HLBL1,HNOSIMP$

 27  SMA1      HCSTM,MPT,HECPT,HGPCT,DIT/HKGGX,,HGPST/C,N,123/C,N,123/V,N,
               HNNLK $

 28  SAVE      HNNLK $

 29  CHKPNT    HKGGX,HGPST $

 30  SMA2      HCSTM,MPT,HECPT,HGPCT,DIT/,HBGG/C,N,1.0/C,N,123/V,N,   HNOBGG=
               -1/C,N,-1 $

 31  SAVE      HNOBGG $

 32  PURGE     HBNN,HBFF,HBAA,HBGG/HNOBGG$

 33  CHKPNT    HBGG,HBNN,HBFF,HBAA $

 34  LABEL     HLBL1 $

 35  RMG       HEST,MATPOOL,HGPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
               V,N,HNLR/V,N,HLUSET $

 36  SAVE      HNLR $

 37  EQUIV     HKGGX,HKGG/HNLR $

 38  PURGE     HRGG,HRNN,HRFF,HRAA,HRDD/HNLR $

 39  CHKPNT    HRGG,HRNN,HRFF,HRAA,HRDD,HKGG,HQGE $

 40  GP4       CASECC,GEOM4,HEQEXIN,HSIL,HGPDT/HRG,,HUSET,/V,N,HLUSET/V,N,
               HMPCF1=-1/V,N,HMPCF2=-1/V,N,HSINGLE=-1/V,N,HOMIT=-1/V,N,HREACT=
               -1/C,N,0/C,N,123/V,N,HNOSET=-1/V,N,HNOL/V,N,HNOA=-1 $

 41  SAVE      HMPCF1,HSINGLE,HOMIT,HNOSET,HREACT,HMPCF2,HNOL,HNOA $

 42  PURGE     HGM,HGMD/HMPCF1/HGO,HGOD/HOMIT/HKFS,HPSO,HQP/HSINGLE $

 43  EQUIV     HKGG,HKNN/HMPCF1/HRGG,HRNN/HMPCF1/HBGG,HBNN/HMPCF1 $

 44  CHKPNT    HGM,HRG,HGO,HKFS,HQP,HUSET,HGMD,HGOD,HPSO,HKNN,HRNN,HBNN $

 45  COND      HLBL2,HNOSIMP $

 46  GPSP      HGPL,HGPST,HUSET,HSIL/HOGPST $

 47  OFP       HOGPST,,,,,//V,N,HCARDNO $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 48  SAVE      HCARDNO $

 49  LABEL     HLBL2 $

 50  COND      HLBL3,HMPCF1 $

 51  MCE1      HUSET,HRG/HGM $

 52  CHKPNT    HGM $

 53  MCE2      HUSET,HGM,HKGG,HRGG,HBGG,/HKNN.HRNN.HBNN. $

 54  CHKPNT    HKNN,HRNN,HBNN $

 55  LABEL     HLBL3 $

 56  EQUIV     HKNN,HKFF/HSINGLE/HRNN,HRFF/HSINGLE/HBNN.HBFF/HSINGLE $

 57  CHKPNT    HKFF,HRFF,HBFF $

 58  COND      HLBL4,HSINGLE $

 59  SCE1      HUSET,HKNN,HRNN,HBNN,/HKFF,HKFS,.HRFF.HBFF. $

 60  CHKPNT    HKFS,HKFF,HRFF,HBFF $

 61  LABEL     HLBL4 $

 62  EQUIV     HKFF,HKAA/HOMIT/HRFF,HRAA/HOMIT/HBFF.HBAA/HOMIT $

 63  CHKPNT    HKAA,HRAA,HBAA $

 64  COND      HLBL5,HOMIT $

 65  SMP1      HUSET,HKFF,,,/HGO,HKAA,,,,,,,, $

 66  CHKPNT    HGO,HKAA $

 67  COND      HLBLR,HNLR $

 68  SMP2      HUSET,HGO,HRFF/HRAA $

 69  CHKPNT    HRAA $

 70  LABEL     HLBLR $

 71  COND      HLBL5,HNOBGG $

 72  SMP2      HUSET,HGO,HBFF/HBAA $

 73  CHKPNT    HBAA $
```

```
RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 74  LABEL     HLBL5 $

 75  DPD       DYNAMICS,HGPL,HSIL,HUSET/HGPLD,HSILD,HUSETD,HTFPOOL,HDLT,,,
               HNLFT,HTRL,,HEQDYN/V,N,HLUSET/V,N,HLUSETD/C,N,123 /V,N,HNODLT/
               C,N,123/C,N,123/V,N,HNONLFT/V,N,HNOTRL/C,N,123/C,N,123/ V,N,
               HNOUE $

 76  SAVE      HLUSETD,HNODLT,HNONLFT,HNOTRL,HNOUE $

 77  COND      HERROR1,HNOTRL$

 78  EQUIV     HGO,HGOD/HNOUE/HGM,HGMD/HNOUE $

 79  PURGE     HPPO,HPSO,HPDO,HPDT/HNODLT $

 80  CHKPNT    HUSETD,HEQDYN,HTFPOOL,HDLT,HTRL,HGOD,HGMD,HNLFT,HSILD,HGPLD,
               HPPO,HPSO,HPDO,HPDT $

 81  MTRXIN    CASECC,MATPOOL,HEQDYN,,HTFPOOL/HK2PP,,HB2PP/V,N,HLUSETD/ V,N,
               HNOK2PP/C,N,123/V,N,HNOB2PP $

 82  SAVE      HNOK2PP,HNOB2PP $

 83  PARAM     //C,N,AND/V,N,HKDEKA/V,N,HNOUE/V,N,HNOK2PP $

 84  PURGE     HK2DD/HNOK2PP/HB2DD/HNOB2PP $

 85  EQUIV     HKAA,HKDD/HKDEKA/HB2PP,HB2DD/HNOA/HK2PP,HK2DD/HNOA/HRAA,HRDD/
               HNOUE $

 86  CHKPNT    HK2PP,HB2PP,HK2DD,HB2DD,HKDD,HRDD $

 87  COND      HLBL6,HNOGPDT $

 88  GKAD      HUSETD,HGM,HGO,HKAA,HBAA,HRAA,,HK2PP,,HB2PP/HKDD,HBDD, HRDD,
               HGMD,HGOD,HK2DD,HM2DD,HB2DD/C,N,TRANRESP/C,N,DISP/C,N, DIRECT/
               C,Y,HG=0.0/C,Y,HW3=0.0/C,Y,HW4=0.0/V,N,HNOK2PP/C,N,-1/   V,N,
               HNOB2PP/V,N,HMPCF1/V,N,HSINGLE/V,N,HOMIT/V,N,HNOUE/ C,N,-1/V,N,
               HNOBGG/V,N,HNOSIMP/C,N,-1 $

 89  LABEL     HLBL6 $

 90  EQUIV     HK2DD,HKDD/HNOSIMP/HB2DD,HBDD/HNOGPDT $

 91  CHKPNT    HKDD,HBDD,HRDD,HGMD,HGOD $

 92  TRLG      CASECC,HUSETD,HDLT,HSLT,HBGPDT,HSIL,HCSTM,HTRL,DIT,HGMD,HGOD,,
               HEST/HPPO,HPSO,HPDO,HPDT,,HTOL/V,N,HNOSET/V,N,HPDEPDO $

 93  SAVE      HPDEPDO,HNOSET $

 94  EQUIV     HPPO,HPDO/HNOSET $
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

```
   N A S T R A N   S O U R C E   P R O G R A M   C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
 NO.

 95  EQUIV     HPDO,HPDT/HPCEPDC $

 96  CHKPNT    HPPO,HPDO,HPSO,HTOL,HPDT $

 97  TRHT      CASECC,HUSETD,HNLFT,DIT,HGPTT,HKDD,HBDD,HRDD,HPDT,HTRL/HUDVT,
               HPNLD/C,Y,BETA=.55/C,Y,TABS=0.0/V,N,HNLR/C,Y,RADLIN=-1 $

 98  CHKPNT    HUDVT,HPNLD $

 99  VDR       CASECC,HEQDYN,HUSETD,HUDVT,HTOL,XYCDB,HPNLD/HOUDV1,HOPNL1/   C,
               N,TRANRESP/C,N,DIRECT/C,N,0/V,N,HNOD/V,N,HNOP/C,N,0 $

100  SAVE      HNOD,HNOP $

101  CHKPNT    HOUDV1,HOPNL1 $

102  COND      HLBL7,HNOD $

103  SDR3      HOUDV1,HOPNL1,,,,/HOUDV2,HOPNL2,,,, $

104  OFP       HOUDV2,HOPNL2,,,,//V,N,HCARDNO $

105  SAVE      HCARDNO $

106  CHKPNT    HOPNL2,HOUDV2 $

110  LABEL     HLBL7 $

111  PARAM     //C,N,AND/V,N,HPJUMP/V,N,HNOP/V,N,JUMPPLOT $

112  COND      HLBL9,HPJUMP $

113  EQUIV     HUDVT,HUPV/HNOA $

114  COND      HLBL8,HNOA $

115  SDR1      HUSETD,,HUDVT,,,HGOD,HGMD,HPSO,HKFS,,/HUPV,,HQP/C,N,1/C,N,
               TRANSNT $

116  LABEL     HLBL8 $

117  CHKPNT    HUPV,HQP $

118  PLTTRAN   HBGPDT,HSIL/HBGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $

119  SAVE      HLUSEP $

120  SDR2      CASECC,HCSTM,MPT,DIT,HEQDYN,HSILD,,HTOL,HBGPDP,HPPC,HCP,HUPV,
               HEST,XYCDB/HOPP1,HOQP1,HOUPV1,HOES1,HOEF1,HPUGV /C,N,
               TRANRESP $

121  SDR3      HOPP1,HOQP1,HOUPV1,HOES1,HOEF1,/HOPP2,HOQP2,HOUPV2,HOES2,
```

RIGID FORMAT DMAP LISTING
SERIES M1

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N

```
DMAP-DMAP INSTRUCTION
 NO.
             HOEF2, $

122  CHKPNT  HOPP2,HOQP2,HOUPV2,HOES2,HOEF2 $

123  OFP     HOPP2,HOQP2,HOUPV2,HOEF2,HOES2.//V.N.HCARDNO $

124  SAVE    HCARDNO $

125  COND    HP2,JUMPPLOT $

126  PLOT    HPLTPAR,HGPSETS,HELSETS,CASECC.HBGPDT.HEQEXIN.HSIP..HPUGV/
             HPLOTX2/V,N,PNSIL/V,N,HLUSEP/V.N.JUMPPLOT/V.N.HPLTFLG/V.N,
             HPFILE $

127  SAVE    HPFILE $

128  PRTMSG  HPLOTX2// $

129  LABEL   HP2 $

130  XYTRAN  XYCDB,HOPP2,HOQP2,HOUPV2,HOES2.HOEF2/HXYPLTT/C.N.TRAN/C.N.PSET/
             V,N,HPFILE/V,N,HCARDNO $

131  SAVE    HPFILE,HCARDNO $

132  XYPLOT  HXYPLTT// $

133  LABEL   HLBL9 $

134  JUMP    FINIS $

135  LABEL   HERROR1 $

136  PRTPARM //C,N,-1/C,N,HDIRTRD$

137  LABEL   FINIS$

138  END     $
```

3.15.2 Description of DMAP Operations for Transient Analysis Heat Transfer

3. GP1 generates grid point location tables and tables relating internal and external degree of freedom indices.

7. Go to DMAP 74 if only direct matrix input.

8. GP2 generates the Element Connection Table.

10. PLTSET transforms user input into plot data tables.

12. PRTMSG prints error messages associated with the structure plotter.

15. Go to DMAP 19 if no structure-only plots are requested.

16. PLØT generates all plots of the structure without temperature profiles.

18. PRTMSG prints plotter data and engineering data for each generated plot.

21. GP3 generates the table of user defined temperature sets and the tables of static heat flux input data.

23. TA1 generates element tables for use in matrix formulation, load generation, and element data recovery.

26. Go to DMAP 34 if no structural or boundary elements exist.

27. SMA1 generates the conductivity matrix, $[K^x_{gg}]$, and the grid point singularity table.

30. SMA2 generates the heat capacity matrix, $[B_{gg}]$.

35. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element-radiation flux matrix, $[Q_{ge}]$, is also generated for use in data recovery.

37. Equivalence the linear heat transfer matrix, $[K_{gg}]$, to the conductivity matrix if no radiation exists.

40. GP4 generates flags defining members of various displacement sets (USET) and forms the multi-point constraint equations, $[R_g]\{u_g\} = 0$.

43. Equivalence $[K_{nn}]$ to $[K_{gg}]$, $[R_{nn}]$ to $[R_{gg}]$, and $[B_{nn}]$ to $[B_{gg}]$ if no multi-point constraints exist.

45. Go to DMAP 49 if no simple elements exist.

46. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

47. ØFP prints the singularity messages.

50. Go to DMAP 55 if no multi-point constraints exist.

51. MCE1 partitions the multi-point constraint equation matrix, $[R_g] = [R_m \vdots R_n]$, and solves for the multi-point constraint transformation matrix,

$$[G_m] = - [R_m]^{-1} [R_n] .$$

53. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] ,$$

$$[R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

$$B_{gg} = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}] [G_m] + [G_m^T] [K_{mm}] [G_m].$$

The same equation is applied to R_{nn} and B_{nn}.

56. Equivalence $[K_{ff}]$ to $[K_{nn}]$, $[B_{ff}]$ to $[B_{nn}]$, and $[R_{ff}]$ to $[R_{nn}]$ if no single point constraints exist.

58. Go to DMAP 61 if no single point constraints exist.

59. SCE1 partitions the matrices as follows:

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

R_{nn} and B_{nn} are partitioned in the same manner, except only the ff partitions are saved.

62. Equivalence $[K_{aa}]$ to $[K_{ff}]$, $[R_{aa}]$ to $[R_{ff}]$, and $[B_{aa}]$ to $[B_{ff}]$ if no omitted coordinates are requested.

64. Go to DMAP 74 if no omitted coordinates are requested.

65. SMP1 partitions the conductivity matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for the transformation matrix $[G_o]$:

$$[K_{oo}]\,[G_o] = -\,[K_{oa}]\ ,$$

and solves for the reduced conductivity matrix $[K_{aa}]$:

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{ao}]\,[G_o]\ .$$

67. Go to DMAP 70 if no radiation matrix exists.

68. SMP2 partitions constrained radiation matrix

$$[R_{ff}] = \left[\begin{array}{c|c} \bar{R}_{aa} & R_{ao} \\ \hline R_{oa} & R_{oo} \end{array}\right]\ ,$$

and performs matrix reduction

$$[R_{aa}] = [\bar{R}_{aa}] + [R_{oa}^T]\,[G_o] + [G_o^T]\,[R_{oa}] + [G_o^T]\,[R_{oo}]\,[G_o].$$

71. Go to DMAP 74 if no heat capacity matrix, $[B_{ff}]$, exists.

72. SMP2 calculates a reduced heat capacity matrix, $[B_{aa}]$, with the same equation as Step 68.

75. DPD generates the table defining the displacement sets each degree of freedom belongs to (USETD), including extra points. It prepares the Transfer Function Pool, the Dynamics Load Table, the Nonlinear Function Table, and the Transient Response List.

77. Go to DMAP 135 and exit if no time step data was specified.

78. Equivalence $[G_o^d]$ to $[G_o]$ and $[G_m^d]$ to $[G_m]$ if no extra points were defined.

81. MTRXIN selects the direct input matrices $[K_{pp}^2]$ and $[B_{pp}^2]$.

85. Equivalence $[K_{dd}^1]$ to $[K_{aa}]$ if no direct input stiffness matrices and no extra points; $[B_{dd}^2]$ to $[B_{pp}]$ and $[K_{dd}^2]$ to $[K_{pp}]$ if only extra points are used; and $[R_{dd}]$ to $[R_{aa}]$ if no extra points are used.

87. Go to DMAP 89 if no structure was defined.

88. GKAD expands the matrices to include extra points and assembles conductivity, capacitance, and radiation matrices for use in Direct Transient Response.

$$[K_{dd}^1] = \left[\begin{array}{c|c} K_{aa} & 0 \\ \hline 0 & 0 \end{array}\right]\ ,$$

$$[B_{dd}^1] = \left[\begin{array}{c|c} B_{aa} & 0 \\ \hline 0 & 0 \end{array}\right]\ ,$$

$$[R_{dd}] = \left[\begin{array}{c|c} R_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[K_{dd}] = [K^1_{dd}] + [K^2_{dd}] ,$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] .$$

(Nonzero values of the parameters W4, G, and W3 are not recommended for use in heat transfer analysis.)

90. Equivalence $[K_{dd}]$ to $[K^2_{dd}]$ and $[B_{dd}]$ to $[B^2_{dd}]$ if no matrices were generated from the structural elements.

92. TRLG generates matrices of heat flux loads versus time. $\{P^o_p\}$, $\{P^o_s\}$, and $\{P^o_d\}$ are generated with one column per output time step. $\{P^t_d\}$ is generated with one column per solution time step, and the Transient Output List is a list of output time steps.

94. Equivalence $\{P^o_d\}$ to $\{P^o_p\}$ if the d and p sets are the same.

95. Equivalence $\{P^t_d\}$ to $\{P^o_d\}$ if the output times are the same as the solution times.

97. TRHT integrates the equation of motion:

$$[B_{dd}]\ \{\dot{u}\} + [K_{dd}]\ \{u\} = \{P_d\} + \{N_d\},$$

where $\{u\}$ is a vector of temperatures at any time,
$\{\dot{u}\}$ is the time derivative of $\{u\}$ ("velocity"),
$\{P_d\}$ is the applied heat flux at any time step, and
$\{N_d\}$ is the total nonlinear heat flux from radiation and/or NØLIN data, extrapolated from the previous solution vector.

The output consists of the $[u^t_d]$ matrix containing temperature vectors and temperature "velocity" vectors for the output time steps.

99. VDR processes the user solution set output requests.

102. Go to DMAP 110 if no solution set output is desired.

103. SDR3 transforms the requested temperature and nonlinear load values into output SØRT2 format.

104. ØFP formats the temperature, temperature velocity, and heat flux nonlinear loads for printout.

112. Go to DMAP 133 and exit if no further output is desired.

113. Equivalence $[u_d]$ to $[u_p]$ if no structure points were input.

114. Go to DMAP 116 if no structure points were input.

115. SDR1 recovers the dependent temperatures:

$$\{u_o\} = [G_o^d] \{u_d\} ,$$

$$\left\{\begin{array}{c} u_d \\ \hdashline u_o \end{array}\right\} = \{u_f\} ,$$

$$\left\{\begin{array}{c} u_f+u_e \\ \hdashline u_s=0 \end{array}\right\} = \{u_n\} ,$$

$$\{u_m\} = [G_m^d] \{u_f+u_e\} ,$$

$$\left\{\begin{array}{c} u_n+u_e \\ \hdashline u_m \end{array}\right\} = \{u_p\} .$$

The module also recovers the heat flux into the points having single-point constraints.

$$\{q_s\} = - \{P_s\} + [K_{fs}^T] \{u_f\}.$$

118. PLTTRAN coverts the grid point tables to standard plot form when grid points with one degree of freedom are used.

120. SDR2 calculates requested heat flux transfer in the elements and transforms temperatures, velocities, and heat flux loads into output form.

121. SDR3 prepares requested output in SØRT2 order.

123. ØFP formats requested output and places it on the system output file.

126. PLØT generates plots of the temperature profile on the structure for specified times.

128. PRTMSG prints plotter data and engineering data for structure plots.

130. XYTRAN prepares tables of requested grid point or element output quantities for XYPLØT.

132. XYPLØT prepares requested plots of temperatures, velocities, element flux, or applied heat loads versus time.

136. TRANSIENT HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.15.3 Restart Tables for Transient Heat Transfer Analysis

3.15.3.1 Bit Positions for Card Name Restart Table

Card Name	Bit Pos.
ADUM1	1
ADUM2	1
ADUM3	1
ADUM4	1
ADUM5	1
ADUM6	1
ADUM7	1
ADUM8	1
ADUM9	1
CDAMP1	1
CDAMP2	1
CDAMP3	1
CDAMP4	1
CELAS1	1
CELAS2	1
CELAS3	1
CELAS4	1
CORD1C	1
CORD1R	1
CORD1S	1
CORD2C	1
CORD2R	1
CORD2S	1
GRDSET	1
GRID	1
SEQGP	1
SPOINT	1
BAROR	2
CBAR	2
CDUM1	2
CDUM2	2
CDUM3	2
CDUM4	2
CDUM5	2
CDUM6	2
CDUM7	2
CDUM8	2
CDUM9	2
CHBDY	2
CHEXA1	2
CHEXA2	2
CONROD	2
CQDMEM	2
CQDMEM1	2
CQDMEM2	2
CQDMEM3	2
CQUAD1	2
CQUAD2	2
CROD	2
CTETRA	2
CTRAPRG	2
CTRIA1	2
CTRIA2	2
CTRIARG	2
CTRMEM	2
CTUBE	2
CWEDGE	2
PBAR	3
PDUM1	3
PDUM2	3
PDUM3	3
PDUM4	3
PDUM5	3
PDUM6	3
PDUM7	3
PDUM8	3
PDUM9	3
PHBDY	3
PQDMEM	3
PQDMEM1	3
PQDMEM2	3
PQDMEM3	3
PQUAD1	3
PQUAD2	3
PROD	3
PTRIA1	3
PTRIA2	3
PTRMEM	3
PTUBE	3
PELAS	6
MAT1	8
MAT2	8
MAT3	8
MAT4	8
MAT5	8
MATT1	8
MATT2	8
MATT3	8
MATT4	8
MATT5	8
TABLEM1	8
TABLEM2	8
TABLEM3	8
TABLEM4	8
TEMPMT$	8
TEMPMX$	8
MPC	9
MPCADD	9
MPC$	9
SPC	10
SPC1	10
SPCADD	10
SPC$	10
ASET	11
ASET1	11
OMIT	11
OMIT1	11
TEMP	13
TEMPD	13
TEMPP1	13
TEMPP2	13
TEMPP3	13
TEMPRB	13
PLOTEL	16
PLOT$	18
POUT$	19
XYOUT$	20
AOUT$	21
LOOP$	22
LOOP1$	23
NOLOOP$	25
RADMTX	55
RADLST	55
SIGMA	55
TREF	55
QBDY1	56
QBDY2	56
QVECT	56
QHBDY	56
QVOL	56
LOAD	56
SLOAD	56
EPOINT	57
SEQEP	57
TF	57
CVISC	58
PDAMP	59
PVISC	59
DMIG	60
B2PP$	60
K2PP$	60
TF$	60
DAREA	61
DELAY	61
DLOAD	61
DLOAD$	61
TABLED1	61
TABLED2	61
TABLED3	61
TABLED4	61
TSTEP$	61
TLOAD1	61
TLOAD2	61
TSTEP	61
BETA	62
IC$	62
NLFORCE	62
NOLIN1	62
NOLIN2	62
NOLIN3	62
NOLIN4	62
RADLIN	62
TIC	62

3.15.3.2 Bit Positions for File Name Restart Table

File Name	Bit Pos.
HBGPDT	94
HCSTM	94
HEQEXIN	94
HGPDT	94
HGPL	94
HSIL	94
HECT	95
HGPTT	96
HECPT	97
HEST	97
HGEI	97
HGPCT	97
HGPST	98
HKGGX	98
HBGG	99
HKGG	100
HRGG	100
HQGE	100
HRG	101
HUSET	101
HOGPST	102
HGM	103
HBNN	104
HKNN	104
HRNN	104
HBFF	105
HKFF	105
HKFS	105
HGO	106
HKAA	106
HDLT	107
HEQDYN	107
HGPLD	107
HNLFT	107
HSILD	107
HTFPOOL	107
HTRL	107
HUSETD	107
HCASEXX	108
HB2PP	109
HK2PP	109
HB2DD	110
HBDD	110
HGMD	110
HGOD	110
HK2DD	110
HKDD	110
HPDT	111
HPNLD	111
HPPT	111
HPST	111
HUDVT	111
HOUDV1	112
HOPNL1	112
HOUDV2	113
HOPNL2	113
HQP	114
HUPV	114
HOEF1	115
HOES1	115
HOPP1	115
HOQP1	115
HOUPV1	115
HPUGV	115
HOEF2	116
HOES2	116
HOPP2	116
HOQP2	116
HOUPV2	116
HELSETS	120
HGPSETS	120
HPLTPAR	120
HPLTSETX	120
HRAA	121
HBAA	122

3.15.3.3 Card Name Restart Table

```
DMAP                       Bit Position
Inst.    1       10        20        30        40        50        60

BEGIN    123  6 890123  6 890123                                 789012
FILE      23  6 890123  6 890123                                 789012
GP1      1
SAVE     1
PURGE    1
CHKPNT   1
COND     1
GP2      12             6                                         8
CHKPNT   12             6                                         8
PLTSET                    8
SAVE                      8
PRTMSG                    8
SETVAL                    8
SAVE                      8
COND                      8
PLOT                      8
SAVE                      8
PRTMSG                    8
LABEL                     8
CHKPNT                    8
GP3      1           3                                6
CHKPNT   1           3                                6
TA1,     123  6      3                                            89
SAVE     123  6      3                                            89
CHKPNT   123  6      3                                            89
COND     123  6 8    3
SMA1     123  6 8    3
SAVE     123  6 8    3
CHKPNT   123  6 8    3
SMA2     123    8    3                                            89
SAVE     123    8    3                                            89
PURGE    123    8    3                                            89
CHKPNT   123    8    3                                            89
LABEL    123  6 8    3
RMG      123  6 8    3                                         5
SAVE     123  6 8    3                                         5
EQUIV    123  6 8    3                                         5
PURGE    123  6 8    3                                         5
CHKPNT   123  6 8    3                                         5
GP4      1       901
SAVE     1       901
PURGE    1       901
EQUIV    123  6 89
CHKPNT   123  6 89
COND     123  6 890
GPSP     123  6 890
OFP      123  6 890
SAVE     123  6 890
LABEL    123  6 890
COND     123  6 89                                             5  89
MCE1     1       9
CHKPNT   1       9
MCE2     123  6 89                                             5  89
CHKPNT   123  6 89                                             5  89
LABEL    123  6 89                                             5  89
EQUIV    123  6 890                                            5  89
CHKPNT   123  6 890                                            5  89
```

Bit Position

DMAP Inst.	1 … 10	20	30	40	50	60	
COND	123 6 890					5 89	
SCE1	123 6 890					5 89	
CHKPNT	123 6 890					5 89	
LABEL	123 6 890					5 89	
EQUIV	123 6 890	1				5 89	
CHKPNT	123 6 890	1				5 89	
COND	123 6 890	1				5 89	
SMP1	123 6 890	1				5	
CHKPNT	123 6 890	1				5	
COND	123 6 890	1				5	
SMP2	123 6 890	1				5	
CHKPNT	123 6 890	1				5	
LABEL	123 6 890	1				5	
COND	123 6 890	1				89	
SMP2	123 6 890	1				89	
CHKPNT	123 6 890	1				89	
LABEL	123 6 890	1				5 89	
DPD	1 90	1				7 0	12
SAVE	1 90	1				7	1
COND	1					7	1
EQUIV	1					7	1
PURGE	1					7	1
CHKPNT	1 90	1				7 0	1
MTRXIN	1					7 0	
SAVE	1					7 0	
PARAM	1					7 0	
PURGE	123 6 890	1				7890	
EQUIV	123 6 890	1				7890	
CHKPNT	123 6 890	1				7890	
COND	123 6 890	1				7890	
GKAD	123 6 890	1				7890	
LABEL	123 6 890	1				7890	
EQUIV	123 6 890	1				7890	
CHKPNT	123 6 890	1				7890	
TRLG	123 6 890	1				5 7	1
SAVE	123 6 890	1				5 7	1
EQUIV	123 6 890	1				5 7	1
EQUIV	123 6 890	1				5 7	1
CHKPNT	123 6 890	1				5 7	1
TRHT	123 6 890	1 3				567890	12
CHKPNT	123 6 890	1 3	23			567890	12
VDR		3 90	1			567890	12
SAVE		3 90	1			567890	12
CHKPNT		3	1			567890	12
COND		3	1			567890	12
SDR3		3	1			567890	12
OFP		3	1			567890	12
SAVE		3	1			567890	12
CHKPNT		3	1			567890	12
XYTRAN							
SAVE							
XYPLOT							
LABEL			1				
PARAM	123 6 890	1	23			7890	12
COND	123 6 890	1	23			7890	12
EQUIV	123 6 890	1	23			7890	12
COND	123 6 890	1	23			7890	12

DMAP Inst.	Bit Position 1 … 10	20	30	40	50	60	
SDR1	123 6 890	1	23			7890	12
LABEL	123 6 890	1	23			7890	12
CHKPNT	123 6 890	1	23			7890	12
PLTTRAN							
SAVE							
SDR2		890					
SDR3		890					
CHKPNT		890					
OFP		9					
SAVE		9					
COND		8					
PLOT		8					
SAVE		8					
PRTMSG		8					
LABEL		8					
XYTRAN		0					
SAVE		0					
XYPLOT		0					
LABEL		0					
JUMP	123 6 890	123 6 890	123			7890	12
LABEL	123 6 890	123 6 890	123			7890	12
PRTPARM	123 6 890	123 6 890	123			7890	12
LABEL	123 6 890	123 6 890	123			7890	12
END	123 6 890	123 6 890	123			7890	12

3.15.3.4 Rigid Format Change Restart Table

DMAP Inst.	Bit Position (63 70 80)
BEGIN	34567890 234
FILE	34567890 234
GP1	
SAVE	
PURGE	
CHKPNT	
COND	
GP2	
CHKPNT	
PLTSET	
SAVE	
PRTMSG	
SETVAL	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
CHKPNT	
GP3	
CHKPNT	
TA1,	
SAVE	
CHKPNT	
COND	
SMA1	
SAVE	
CHKPNT	
SMA2	3 678
SAVE	3 678
PURGE	3 678
CHKPNT	3 678
LABEL	
RMG	
SAVE	
EQUIV	
PURGE	
CHKPNT	
GP4	
SAVE	
PURGE	
EQUIV	
CHKPNT	
COND	
GPSP	
OFP	
SAVE	
LABEL	
COND	
MCE1	
CHKPNT	
MCE2	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	

DMAP Inst.	Bit Position (63 70 80)
COND	
SCE1	
CHKPNT	
LABEL	
EQUIV	
CHKPNT	
COND	
SMP1	
CHKPNT	
COND	
SMP2	
CHKPNT	
LABEL	
COND	
SMP2	
CHKPNT	
LABEL	
DPD	
SAVE	
COND	
EQUIV	
PURGE	
CHKPNT	
MTRXIN	
SAVE	
PARAM	
PURGE	
EQUIV	
CHKPNT	
COND	
GKAD	
LABEL	
EQUIV	
CHKPNT	
TRLG	
SAVE	
EQUIV	
EQUIV	
CHKPNT	
TRHT	
CHKPNT	
VDR	
SAVE	
CHKPNT	
COND	
SDR3	
OFP	
SAVE	
CHKPNT	
XYTRAN	
SAVE	
XYPLOT	
LABEL	
PARAM	34567890 234
COND	34567890 234
EQUIV	34567890 234
COND	34567890 234

DMAP Inst.	Bit Position 63 70 80
SDR1	34567890 234
LABEL	34567890 234
CHKPNT	34567890 234
PLTTRAN	
SAVE	
SDR2	
SDR3	
CHKPNT	
OFP	
SAVE	
COND	
PLOT	
SAVE	
PRTMSG	
LABEL	
XYTRAN	
SAVE	
XYPLOT	
LABEL	
JUMP	34567890 234
LABEL	34567890 234
PRTPARM	34567890 234
LABEL	34567890 234
END	34567890 234

3.15.3.5 File Name Restart Table

```
DMAP              Bit Position
Inst.     94   100       110       120

BEGIN
FILE
GP1       4
SAVE      4
PURGE
CHKPNT
COND
GP2        5
CHKPNT     5
PLTSET                              0
SAVE                                0
PRTMSG                              0
SETVAL                              0
SAVE                                0
COND
PLOT
SAVE
PRTMSG
LABEL
CHKPNT                              0
GP3         6
CHKPNT      6
TA1,         7
SAVE         7
CHKPNT       7
COND          8
SMA1          8
SAVE          8
CHKPNT        8
SMA2           9
SAVE           9
PURGE          9
CHKPNT         9
LABEL         89
RMG             0
SAVE            0
EQUIV           0
PURGE           0
CHKPNT          0
GP4              1
SAVE             1
PURGE            1 3 56   01  4
EQUIV               4
CHKPNT              4
COND              2
GPSP              2
OFP               2
SAVE
LABEL             2
COND               34
MCE1               3
CHKPNT             3
MCE2                4
CHKPNT              4
LABEL              34
EQUIV                5
CHKPNT               5
```

DMAP Inst.	94	100	110	120
COND		5		
SCE1		5		
CHKPNT		5		
LABEL		5		
EQUIV		6		12
CHKPNT		6		12
COND		6		12
SMP1		6		
CHKPNT		6		
COND				1
SMP2				1
CHKPNT				1
LABEL				1
COND				2
SMP2				2
CHKPNT				2
LABEL		6		12
DPD		7		
SAVE		7		
COND				
EQUIV			0	
PURGE		7		
CHKPNT		7		
MTRXIN		9		
SAVE		9		
PARAM		9		
PURGE			0	
EQUIV			0	
CHKPNT			0	
COND			0	
GKAD			0	
LABEL			0	
EQUIV			0	
CHKPNT			0	
TRLG			1	
SAVE			1	
EQUIV			1	
EQUIV			1	
CHKPNT			1	
TRHT			1	
CHKPNT			1	
VDR			2	
SAVE			2	
CHKPNT			2	
COND			3	
SDR3			3	
OFP				
SAVE				
CHKPNT			3	
XYTRAN				
SAVE				
XYPLOT				
LABEL				
PARAM			4	
COND			4	
EQUIV			4	
COND			4	

```
DMAP                      Bit Position
Inst.       94       100               110         120

SDR1                                      4
LABEL                                     4
CHKPNT                                    4
PLTTRAN                                    5
SAVE                                       5
SDR2                                       5
SDR3                                        6
CHKPNT                                      6
OFP
SAVE
COND
PLOT
SAVE
PRTMSG
LABEL
XYTRAN
SAVE
XYPLOT
LABEL                                     4
JUMP
LABEL
PRTPARM
LABEL
END
```

3.15.4 Case Control Deck and Parameters for Transient Heat Transfer Analysis

The following items relate to subcase definition and data selection for Transient Heat Transfer Analysis:

1. A single subcase must be defined with a single constraint condition.

2. DLØAD and/or NØNLINEAR must be used to define a single time-dependent loading condition. The static load cards (QVECT, QVØL, QHBDY, QBDY1, and QBDY2) can be used to define a dynamic load by using these cards with, or instead of, the DAREA cards. The set identification number on the static load cards (field 2) is used in the same manner as the set identification number on the DAREA cards (field 2).

3. TSTEP must be used to select the time-step intervals to be used for integration and output.

4. If nonzero initial conditions are desired, IC must be used to select a TEMP set in the Bulk Data Deck.

5. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP MATERIAL request if radiation effects are included.

The following printed output, sorted by print number or element number (SØRT2), is available at selected multiples of the integration time step:

1. Temperatures (THERMAL or SDISPLACEMENT) and derivatives of temperatures (VELØCITY or SVELØCITY) for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formation of dynamic equation).

2. Nonzero components of the applied load vector (ØLØAD) and constrained heat flow (SPCFØRCE) for a list of PHYSICAL points.

3. Nonlinear load vector for a list of SØLUTIØN points.

4. Flux density (ELFØRCE) in selected elements (ALL not allowed).

TRANSIENT HEAT TRANSFER ANALYSIS

The following plotter output is available for Transient Heat Transfer Analysis:

1. Undeformed plot of the structural model.
2. Temperature profiles for selected time intervals.
3. X - Y plot of temperature or derivative of temperature for a PHYSICAL point or SØLUTIØN point.
4. X - Y plot of the applied load vector, nonlinear load vector, or constrained heat flow.
5. X - Y plot of flux density for an element.

The data used for preparing the X - Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X - Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Transient Heat Transfer Analysis:

1. TABS - optional - the real value of this parameter is the absolute reference temperature.
2. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant.
3. BETA - optional - the real value of this parameter is used as a factor in the integration algorithm.
4. RADLIN - optional - a positive integer value of this parameter causes some of the radiation effects to be linearized.

4.1 PLOTTING

NASTRAN provides the capability for generating on any of several different plotters the following kinds of plots:

1. Undeformed geometric projections of the structural model.
2. Static deformations of the structural model by either displaying the deformed shape (alone or superimposed on the undeformed shape), or displaying the displacement vectors at the grid points (superimposed on either the deformed or undeformed shape).
3. Modal deformations (sometimes called mode shapes or eigenvectors) resulting from real eigenvalue analysis by the same options stated in 2 above.
4. Transient deformations of the structural model by displaying either vectors or the deformed shape for specified times.
5. X-Y graphs of transient response or frequency response.
6. Topological displays of matrices.

Structure plots (items 1-4) are discussed in Section 4.2 while X-Y plots (item 5) are discussed in Section 4.3. Matrix plots are generated by Utility Module SEEMAT described in Section 5 and must be accomplished by altering a Rigid Format or using a DMAP sequence. Requests for structure plots or X-Y plots are accomplished in the Case Control Deck by submitting a structure plot request packet or an X-Y output request packet. The discussion of these packets constitutes most of the remainder of this chapter. The optional PLØTID card is considered to be part of the plot packets (although it must preceed any ØUTPUT(PLØT), ØUTPUT(XYØUT), or ØUTPUT(XYPLØT) cards, see page 2.3-38).

In order to actually create plots, a plotter and model name must be specified by the user. The method used to specify this information may vary according to the plot request made, but the actual names used do not vary. In addition, a physical plot tape must be set up by the user. The control cards needed to set up a plot tape are generally installation dependent and are described in Section 5 of the Programmer's Manual. There are two plot tapes (PLT1 and PLT2). It is only necessary to set up the plot tape used by the specified plotter. The number of plots for PLT1 on IBM 360 computers is limited (see Section 5.3.5 of the Programmer's Manual).

The following table is a list of permissible plotter and model names, together with the corresponding plot tapes which must be set up by the user. The underlined items are the default models for each plotter. A model name is generally specified as two items, each having a default value. The default value of the second item is in some cases dependent upon the value specified for the first item. If no plotter is specified by the user, the requested plots will be created for the Stromberg Carlson (SC) model 4020 microfilm plotter.

Plotter Name	Plot Tape	Plotter Model
BL	PLT1	$\left\{\begin{matrix}\underline{\text{STE}}\\\text{LTE}\end{matrix}\right\}$, $\underline{30}$
CALCØMP	PLT2	$\left\{\begin{matrix}\underline{765}\\763\end{matrix}\right\}$, $\left\{\begin{matrix}\underline{205}\\210\\105\\110\end{matrix}\right\}$ $\left\{\begin{matrix}565\\563\end{matrix}\right\}$, $\left\{\begin{matrix}\underline{205}\\210\\105\\110\\305\\310\end{matrix}\right\}$
DD	PLT2	$\underline{80}$,$\underline{\text{B}}$
EAI	PLT1	$\underline{3500}$,$\left\{\begin{matrix}\underline{30}\\45\end{matrix}\right\}$
NASTPLT	PLT2	$\left\{\begin{matrix}\underline{\text{M}}\\\text{T}\\\text{D}\end{matrix}\right\}$, $\left\{\begin{matrix}\underline{0}\\\text{T}\end{matrix}\right\}$
$\underline{\text{SC}}$	PLT2	$\underline{4020}$

The plotter name, BL, is used for Benson Lehner plotters. The default model is an STE, 30. The first model item may be either STE or LTE, where STE is a short line electroplotter and LTE is a long line electroplotter. The second model item may only equal 30, which is the size of the plotter table in inches. Both the STE and LTE plotters are table plotters.

The plotter name, CALCØMP, is used for California Computer plotters. The default model is a 765, 205. The first model item is the plotter model number as used in California Computer hardware descriptions. The 700 series plotters are those having the ZIP mode and 24 incremental directions. The 500 series plotters are those having only 8 incremental directions. The 600 series may have either 24 or 8 incremental directions. If the user has access to only a 663 or 665 plotter, it should be specified as a 563 or 565 if it has only 8 incremental directions, and as a 763 or 765 if it has 24 incremental directions. The 563 and 763 are both 30-inch drum plotters, while the 565 and 765 are both 12-inch drum plotters.

The second model item indicates the type of tape transport used with the CALCØMP plotter and the increment size of the plotter. There are two possible increment sizes, .010 and .005 inches. The last two digits of this second model item represent these two possible increment sizes, i.e., 10 = .010 and 05 = .005. The first digit of the second model item represents the type of tape transport attached to the plotter. There are three types of tape transports available. The primary differences among these transports are the number of characters needed to cause one incremental movement on the plotter. Some transports (e.g. the 470, 570 and 750 models) require three characters. These transports can only be attached to the 500 series plotters. Other transports (e.g. the 760 and 770) require two characters for each incremental movement. Still other transports (e.g. the 780) require only one character for each incremental movement. The first digit of the second model item is the number of characters required by the tape transport for each incremental movement. An example of a legitimate CALCØMP model name is (763,105). This represents a 763, 30-inch drum plotter with an increment size of .005 inches, driven by a tape transport requiring only one character for each incremental movement (e.g. a 780 tape transport).

The plotter name, DD, is used for Data Display plotters. The only permissible model is the (80,B) microfilm plotter.

The plotter name, EAI, is used for Electronic Associates Inc. plotters. The first model item is the model number as described in EAI hardware descriptions. The only permissible model is an EAI 3500. This is a table plotter having either a 30-inch or 45-inch plotting surface. The second model item is the size of the plotting surface. The default size is a 30-inch surface, i.e., 3500, 30.

The plotter name, NASTPLT, is used for the NASTRAN General Purpose plotter package. This plotter package is used if the desired plotter is not available in the NASTRAN plotting software. However, if this package is specified, a separate program must be written to interpret the resulting plot tape and create the corresponding plots on the actual plotter desired. The default model is M, 0. The first model item may either be M, T, or D. This indicates the actual plotter is a microfilm, table or drum plotter, respectively. The second model item indicates whether or not the actual plotter has any typing capability: 0 = typing possible, 1 = no typing possible. If no typing capability exists, all printed characters will be drawn. The default plotter type is a microfilm plotter with typing capability. An example of an acceptable model is (T,1). This represents a table plotter having no typing capability. A more detailed description of the

implications of the NASTRAN General Purpose plotter package is given in Section 6 of the Programmer's Manual.

The plotter name, SC, is used for Stromberg Carlson plotters. The only permissible model is the 4020 microfilm plotter. If the only available plotter model is a 4060, the user should determine if it has a 4020 compatibility package, as is usually the case, so as to avoid using the NASTRAN General Purpose plotter.

The operation of the Structure Plotter is of sufficient theoretical content to warrant inclusion in the Theoretical Manual. Section 13 of the Theoretical Manual provides a discussion of the basic theory and gives some examples of plotter output.

The availability of NASTRAN plotting capability is a function of the particular rigid format as shown in the following table. Note that deformed structure plots are not available for either frequency response rigid formats or complex eigenvalue analysis rigid formats. Complex numbers are the source of this restriction.

Plotter Availability for the NASTRAN Rigid Formats

Rigid Format	Structure Plotter		Curve Plotter	Matrix Topology Plotter
	Undeformed	Deformed		
1	x	x		*
2	x	x		*
3	x	x		*
4	x	x		*
5	x	x		*
6	x	x		*
7	x			*
8	x		x	*
9	x	x	x	*
10	x			*
11	x		x	*
12	x	x	x	*

* The matrix topology plotter is not automatically available in any rigid format. Utility module SEEMAT must be altered into the Rigid Format DMAP sequence in order to use this feature (see Section 5.2).

4.2 STRUCTURE PLOTTING

In order to assist NASTRAN users both in the preparation of the analytical model and in the interpretation of output, the structure plotter provides the following capabilities for undeformed structures:

1. Place a symbol at the grid point locations. (optional)
2. Identify grid points by placing the grid point identification number to the right of the grid point locations. (optional)
3. Identify elements by placing the element identification number and element symbol at the center of each element. (optional)
4. Connect the grid points in a predetermined manner using the structural elements or PLØTEL elements.

The following capabilities are provided for deformed structures:

1. Place a symbol at the deflected grid point location. (optional)
2. Identify the deflected grid points by placing the grid point identification number to the right of the deflected grid point locations. (optional)
3. Connect the deflected grid points in a predetermined manner using the structural elements or PLØTEL elements.
4. Draw lines originating at the undeflected or deflected grid point location, drawn to user-specified scale, representing the X, Y, Z components or resultant summations of the grid point deflections.

The above plots are available in either orthographic, perspective, or stereoscopic projections on several plotters. Stereoscopic plots are normally made only on microfilm plotters since a stereoscopic viewer or projector must be used to obtain the stereoscopic effect. A request for structure plotting is made in the Case Control Deck by means of a plot request packet which includes all cards from an ØUTPUT(PLØT) card to either a BEGIN BULK or ØUTPUT(XYØUT) [or ØUTPUT(XYPLØT)] card. It should be noted that only elements can be plotted. Grid points that are not associated with elements cannot be plotted. Grid points may be connected with PLØTEL elements for plotting purposes.

The data card format is free-field, subject to rules in paragraphs below. The cards are basically sequence dependent even though some interchanging in sequence of defining parameters is permissible. The elements and grid points to be plotted may be defined anywhere in the submittal, but the parameters describing the characteristics of the plot are evaluated on the current basis every time a PLØT or FIND card (see Section 4.2.2.2) is encountered. In order to minimize mistakes, it is suggested that a strict sequence dependency be assumed.

4.2.1 General Rules

4.2.1.1 Rules for Free-Field Card Specification

1. Only columns 1 thru 72 are available. Any information specified in columns 73 thru 80 will be ignored.

2. If the last character on a card is a comma (not necessarily in column 72), the next card is a continuation of this physical card. Any number of continuation cards may be specified, and together they form a logical card.

3. The mnemonics or values can be placed anywhere on the card, but must be separated by delimiters.

4. The following delimiters are used:

   a. blank

   b. , comma

   c. (left parenthesis

   d.) right parenthesis

   e. = equal sign

   All of these delimiters can be used as needed to aid the legibility of the data.

4.2.1.2 Plot Request Packet Card Format

In the plot request packet card descriptions presented in Section 4.2.2, the following notation will be used to describe the card format:

1. Upper-case letters must be punched exactly as shown.

2. Lower-case letters indicate that a substitution must be made.

3. Braces { } indicate that a choice of the contents is mandatory.

4. Brackets [ ] contain an option that may be omitted or included by the user.

5. Underlined options or values are those for which a default option or an initialized (or computed) value was programmed.

6. A physical card consists of information punched in columns 1 through 72 of a card.

7. A logical card may consist of more than one physical card through the use of continuation cards.

8. Numerical values may always be either integer or real numbers, even though a specific type is at times suggested in order to conform to the input in other sections of the program.

4.2.1.3 Plot Titles

Up to four lines of title information will be printed in the lower left-hand corner of each plot. The text for the top three lines is taken from the TITLE, SUBTITLE, and LABEL cards in the

Case Control Deck. (See Sections 2.3.2 and 2.3.4 for a description of the TITLE, SUBTITLE, and LABEL cards.) The text for the bottom line may be of three forms depending on the type plot requested. One form contains the word UNDEFØRMED SHAPE. Another form contains the words STATIC DEFØRMATIØN with subcase and load set identification. The third form contains the words MØDAL DEFØRMATIØN with subcase and mode identification and the value of the corresponding eigenvalue.

The sequence number for each plot is printed in the upper corners of each frame. The sequence number is determined by the relative position of each PLØT execution card in the plot package.

4.2.2 Plot Request Packet Card Descriptions

The general form for each card of the plot request packet is shown enclosed in a rectangular box. Description of the card contents then follows for each card.

4.2.2.1 SET Definition Cards

These cards specify sets of elements, corresponding to portions of the structure, which may be referenced by PLØT and FIND cards. The SET card is required.

Each set of elements defines by implication a set of grid points connected by those elements. The set may be modified for plotting deformation data by deleting some of its grid points. The elements are used for creating the plot itself and element labeling while the grid points are used for labeling, symbol printing, and drawing deformation vectors.

SET i [INCLUDE] [ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5, etc.
[INCLUDE / EXCLUDE / EXCEPT] [ELEMENTS / GRID POINTS] k_1, k_2, k_3 THRU k_4, k_5, etc.

i = set identification number (positive integer, unique for each set)

j = element identification numbers or element types

k = element identification numbers or grid point identification numbers or element types

Permissible element types are:

RØD, CØNRØD, BAR, TUBE, VISC, TRIA1, TRIA2, TRBSC, TRPLT, TRMEM,

QUAD1, QUAD2, QDPLT, QDMEM, QDMEM1, QDMEM2, SHEAR, TWIST, PLØTEL

ALL may be used to select all permissible element types.

INCLUDE may be used at any time for element information. When used with grid points, INCLUDE can be used only to restore previously EXCLUDEd grid points. It cannot be used to include grid points in the original set of grid points.

EXCLUDE can be used to delete elements or element types. All grid points that are associated with deleted elements are also deleted. EXCLUDE can be used to delete deformation vectors from grid points enumerated after an EXCLUDE command.

EXCEPT is a modifier to an INCLUDE or an EXCLUDE statement.

THRU is used to indicate all of the integers in a sequence of identification numbers, starting with the integer preceding THRU and ending with the integer following THRU. The integers in the range of the THRU statement need not be consecutive, e.g., the sequence 2, 4, 7, 9 may be specified

as 2 THRU 9.. THRU is not applicable if element types are specified.

Each SET must be a logical card. Redefinition of sets previously defined is not permitted; however, there is no restriction on the number of sets. The sets of identification numbers can be assembled by use of the word ALL, or by individually listing the integers in any order such as 1065, 32, 46, 47, 7020, or by listing sequences using THRU, EXCLUDE, and EXCEPT such as 100 THRU 1000 EXCEPT 182 EXCLUDE 877 THRU 911. Examples of SET cards:

Examples of SET cards:

1. SET 1 INCLUDE 1, 5, 10 THRU 15 EXCEPT 12
   (Set will consist of elements 1, 5, 10, 11, 13, 14 and 15)

2. SET 25 = RØD, CØNRØD, EXCEPT 21
   (Set will consist of all RØD and CØNRØD elements except element 21)

3. SET 10 SHEAR EXCLUDE GRID PØINTS 20, 30 THRU 60, EXCEPT 35,
   36 INCLUDE ELEMENTS 70 THRU 80.
   (This set will include all shear elements plus elements 70 thru 80, and the associated grid point set will contain all grid points connected by these elements. Grid points 20, 30 thru 34 and 37 thru 60 will appear on all plots with their symbols and labels, however no deformation vectors will appear at these grid points when VECTØR is commanded.

4. SET (15) = (15 THRU 100) EXCEPT (21 THRU 25)
   (This set will include all elements from 15 to 20 and from 26 to 100).

5. SET 2 = ALL EXCEPT BAR
   (This set will include all elements except bars).

NOTE: The equal signs, commas, and parentheses above are delimiters and are not required, because blanks also serve as delimiters.

4.2.2.2 Cards Defining Parameters

These cards specify how the structure will be plotted, i.e., type of projection, view angles, scales, etc. All the multiple choice parameters are defaulted to a preselected choice if not specified. Each parameter requiring a numerical value that is not specified by the user can either be established internally in the program by means of the FIND card or can assume default values. The FIND card is used to request that the program select a SCALE, ØRIGIN, and/or VANTAGE PØINT to allow the construction of a plot in a user-specified region of the paper or film. The FIND card is described at the end of this Section, following the discussion of the associated parameters.

The parameter cards are listed here in a logical sequence; however, they need not be so specified. Any order may be used, but if a parameter is specified more than once, the value or choice stated last will be used. Each parameter may be either an individual card, or any number of them may be combined on one logical card.

All the parameters used in the generation of the various plots will be printed out as part of the output, whether they are directly specified, defaulted or established using the FIND card.

Initialization of parameters to default values occurs only once. Subsequently, these values remain until altered by a direct input. The only exceptions are the view angles, scale factors, vantage point parameters, and the origins. Whenever the plotter or the method of projection is changed, the view angles are reset to the default values, unless they are respecified by the user. In addition, the scale factors, vantage point parameters, and the origin must be redefined by the user.

```
                                            ┌        (800)       ┐
PLØTTER  plotter name, MØDEL name           │DENSITY {556}  BPI  │
                                            └        (200)       ┘
```

The plotter names and MØDEL names are listed in Section 4.1. The tape density information is used only in print-out and does not control the density of the generated plot tape. To actually specify the tape density, the user must use the customary means of communication established at a given installation between the user and the computer operators. This card is required for plotters other than the SC 4020.

```
(ØRTHØGRAPHIC)
{PERSPECTIVE }  PRØJECTIØN
(STEREØSCØPIC)
```

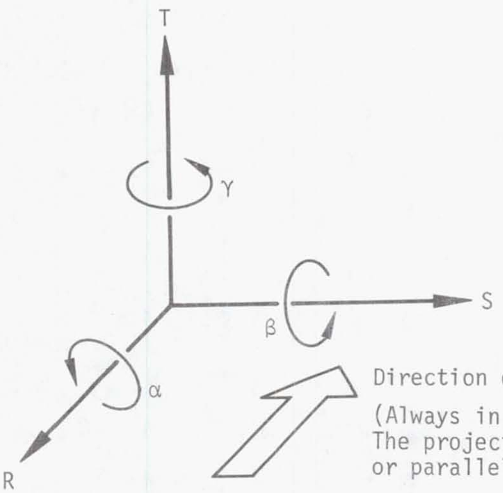
The default option is orthographic projection. See Section 13 of the Theoretical Manual for a discussion of the various projections. This card is optional.

AXES r, s, t	[SYMMETRIC / ANTISYMMETRIC]
VIEW γ, β, α	

r, s, t = X or MX, Y or MY, Z or MZ (where "M" implies the negative axis)

γ, β, α = three angles of rotation in degrees (real numbers)

These two parameter cards define the orientation of the object in relation to the observer, that is the angles of view. Both of these cards are optional. Defining the observer's coordinate system as R, S, T and the basic coordinate system of the object as X, Y, Z, the angular relationship between the two systems is defined by the three angles γ, β and α as follows:



Using the above convention, γ and β represent the angles of turn and tilt. The default values are:

γ = 34.27°

β = 23.17° for orthographic and stereoscopic projections

0.0° for perspective projection

α = 0.0° .

The order in which γ, β, and α are specified is critically important as illustrated in Figure 1, at the end of this section. Also, see section 13.1.1 of the Theoretical Manual.

The AXES card can be used to preposition the object in 90° increments in such a manner that only rotations less than 90° are required by the VIEW card to obtain the desired orientation. This is accomplished by entering X, Y, Z, MX, MY or MZ in the fields corresponding to R, S, T axes, where MX, MY and MZ represent the negative X, Y and Z axis directions respectively. The default values are X, Y, Z.

An undeformed or deformed plot of the symmetric portion of an object can be obtained by reversing the sign of the axis that is normal to the plane of symmetry. In the case of multiple planes of symmetry, the signs of all associated planes should be reversed. The ANTISYMMETRIC option should be specified when a symmetric structure is loaded in an unsymmetric manner. This will cause the deformations to be plotted antisymmetrically with respect to the specified plane or

planes. Since the AXES card applies to all parts (SETS) of a single frame, symmetric and antisymmetric combinations cannot be made with this card (see the symmetry option on the PLØT execution card in Section 4.2.2.3).

MAXIMUM DEFØRMATIØN d

This card must always be included if a deformed structure is to be plotted. The value of d represents the length to which the maximum displacement component is scaled in each subcase. The maximum deformation of the structure must be specified in units of the structure (not inches of paper). This data is necessary since the actual deformations are usually too small to be distinguishable from the undeformed structure if they were plotted to true scale. If FIND card parameters are to be based on the deformed structure, the FIND card must be preceded by the MAXIMUM DEFØRMATIØN card.

SCALE a[, b]

a = real number representing scale to which the model is drawn

b = ratio of model size/real object size (stereoscopic projection only)

For orthographic or perspective projections, the scale "a" is the ratio of the plotted object in inches to the real object in the units of the structural model, i.e., one inch of paper equals one unit of structure. For stereoscopic projection, the stereoscopic effect is enhanced by first reducing the real object to a smaller model (scale "b"), and then applying scale "a". The ratio of plotted/real object is then the product a x b. A scale must be defined in order to make a plot, however, the SCALE card is not recommended for general use. See the FIND card described at the end of this Section in order to have the scale determined automatically.

$$\boxed{\text{ØRIGIN} \quad i,\ u,\ v}$$

i = origin identification number (any positive integer)

u = horizontal displacement of paper origin from RST origin

v = vertical displacement of paper origin from RST origin

In the transformation performed for any of the three projections, the origins of both the object (XYZ system) and of the observer (RST system) are assumed to be coincident.

This card refers to the paper origin. It represents the displacement of the paper origin (lower left hand corner) from the RST origin. The units are inches and are not subject to the scaling of the plotted object. The ØRIGIN card is not recommended for general use. See the FIND card described at the end of this Section in order to have the origin located so as to place the plotted object in the center of the image area.

Ten (10) origins are permitted to be active at one time. However, any one can be redefined at any time. An eleventh origin is also provided if more than 10 origins are erroneously defined (i.e., only the last of these surplus origins will be retained). CAUTION: when a new projection or plotter is called for, all previously defined origins are deleted.

$$\boxed{\text{VANTAGE PØINT} \quad r_o,\ s_o,\ t_o\ [,\ s_{or}]}$$

(perspective and stereoscopic projections only)

r_o = R-coordinate of the observer

s_o = S-coordinate of the observer in perspective projection or
S-coordinate of the left eye of the observer in the stereoscopic projection

t_o = T-coordinate of the observer

s_{or} = S-coordinate of the right eye of the observer in the stereoscopic (not needed in perspective projection)

This card defines the location of the observer with respect to the structural model. A vantage point is required for either perspective or stereoscopic projections. The VANTAGE PØINT card is not recommended for general use. See the FIND card described at the end of this Section. A theoretical description of vantage point is contained in Section 13 of the Theoretical Manual.

PRØJECTIØN PLANE SEPARATIØN d_o

(perspective and stereoscopic projections only)

This card specifies the R-direction separation of the observer and the projection plane.

The PRØJECTIØN PLANE SEPARATIØN card is not recommended for general use. See the FIND card described at the end of this Section. The card may be ommitted if VANTAGE PØINT is included on the FIND card. A theoretical description of projection plane separation is contained in Section 13 of the Theoretical Manual.

ØCULAR SEPARATIØN os

(stereoscopic projection only)

Ocular separation - S-coordinate separation of the two vantage points in the stereoscopic projection is defaulted to 2.756 inches which is the separation used in the standard stereoscopic cameras and viewers (70mm). It is recommended that the default value be used.

CAMERA type [, BLANK FRAMES n]

(microfilm plotters only)

This card offers three options of different cameras or combinations:

type = FILM - 35mm or 16mm film (positive or negative images)

type = PAPER - positive prints

type = BØTH - positive prints and 35mm or 16mm film

The request for a 35mm or 16mm camera and positive or negative images must be communicated to the plotter operator through normal means of communications at the installation. Insertion of blank frames between plots is optional and is applicable only to plots generated on film. The type option must be FILM or BØTH if blank frames are desired. The plotter must be operated in the manual mode in order to have blank frames inserted between positive prints. If blank frames are desired only on film, and not on paper, the plotter must be operated in the automatic mode. The

default values are type = PAPER, n = 1. This card is completely optional.

$$\boxed{\text{PAPER SIZE} \quad a \begin{Bmatrix} X \\ BY \end{Bmatrix} \; b, \text{[TYPE name]}}$$

(table plotters only)

a = horizontal size of paper in inches

b = vertical size of paper in inches

name = any BCD value desired by user for identification purposes.

The default parameters are 8.5 x 11.0, type VELLUM. This card is completely optional.

$$\boxed{\text{PEN i [, SIZE j] [, CØLØR name]}}$$

(table plotters only)

i = pen designation number

j = pen size number (0 thru 3)

name = color desired

This card generates a message on the printed output which may be used to inform the plotter operator as to what size and which color pen point to mount in the various pen holders. The actual number of pens available will depend on the plotter hardware configuration at each installation. This card does not control the pen used in generating the plot (see the PEN option on the PLØT execution card in Section 4.2.2.3). The PEN card is optional, and is not appropriate for microfilm plotters.

The pen designations vary on various plotters; therefore, the designation numbers used here are only the pointers to true identification of the pens. The following table summarizes these pen designations and the acutal pen numbers on the plotters used.

NASTRAN Pen Designation	PLOTTER Pen Number	
	EAI 3500	All Others
1	0	1
2	1	2
3	2	3
4	3	4
5	4	1
6	5	2
7	6	3
8	7	4

FIND [SCALE],[ØRIGIN i],[VANTAGE PØINT],[SET j],[REGIØN le,be,re,te]

i = origin identification number (any positive integer).

j = set identification number (any positive integer).

le = fractional distance of <u>left</u> edge of plot region from the lower left corner of the image area (default value = 0).

be = fractional distance of <u>bottom</u> edge of plot region from the lower left corner of the image area (default value = 0).

re = fractional distance of <u>right</u> edge of plot region from the lower left corner of the image area (default value = 1.).

te = fractional distance of <u>top</u> edge of plot region from the lower left corner of the image area (default value = 1.).

The FIND card requests the structure plotter to compute any of the parameters SCALE, ØRIGINi, and/or VANTAGE PØINT indicated by the user based on (a) the plotter requested on the PLØTTER card, (b) the projection requested on the PRØJECTION card, (c) SETj and REGIØN le, be, re, te requested on the FIND card, (d) the orientation requested on the VIEW and/or AXES card(s), (e) the deformation scaling requested on the MAXIMUM DEFØRMATIØN card, and (f) the paper size for table plotters as requested on the PAPER SIZE card. All dependencies on which a FIND card is based must precede the FIND card.

Any one, two, or all three parameters may be computed by the program by using this card, provided that the parameters not requested have already been defined. If no set is specified on this card, the first set defined is used by default. If no options are specified on the FIND card, a SCALE and VANTAGE PØINT are selected and ØRIGIN 1 is located, using the first defined SET, so that the plotted object is located within the image area. The plot region is defined as some fraction of the image area (image area = 0, 0, 1., 1. and first quadrant = .5, .5, 1., 1.). The image area is located inside the margins on the paper. Each FIND card must be <u>one</u> (1) logical card. The FIND card is recommended for general use.

4.2.2.3 PLØT Execution Card

```
     ┌ ⎧STATIC   ⎫                                       ┐ ┌ ⎧RANGE λ1, λ2⎫ ┐
PLØT │ ⎨MØDAL    ⎬ DEFØRMATIØN i1, i2 THRU i3, i4, etc.  │ │ ⎩TIME  t1, t2⎭ │ [MAXIMUM DEFØRMATIØN d],
     └ ⎩TRANSIENT⎭                                       ┘ └                ┘

                   ┌⎧SYMMETRY    ⎫  ┐┌⎧PEN    ⎫  ┐                      ┌      ⎧GRID PØINTS⎫┐
[SET j1][ØRIGIN k1]│⎨             ⎬ w││⎨       ⎬ p│[SYMBØLS m[, n]]│LABEL⎨ELEMENTS   ⎬│,
                   └⎩ANTISYMMETRY⎭  ┘└⎩DENSITY⎭  ┘                      └      ⎩BØTH       ⎭┘

┌                  ┐
│SHAPE             │
│VECTØR v          │ ,
│SHAPE, VECTØR v   │
└                  ┘

[SET j2][ØRIGIN k2] .... etc.
```

This logical card will cause one picture to be generated for each subcase, mode or time step requested, using the current parameter values. If only the word PLØT appears on the card, a picture of the undeformed structure will be prepared using the first defined set and the first defined origin. The available plot options and their meanings are:

1. STATIC - Plot static deformations in Rigid Formats 1, 2, 4, 5, and 6.

   MØDAL - Plot mode shapes in Rigid Formats 3 and 5.

   TRANSIENT - Plot transient deformations in Rigid Formats 9 and 12.

2. DEFØRMATIØN - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" with command.

3. RANGE - Refers to range of eigenvalues (not frequency range or mode numbers), using requested subcases, for which plots will be prepared.

   TIME - Refers to time interval, using requested subcases and output time steps, for which plots will be prepared.

4. MAXIMUM DEFØRMATIØN - Real number following is used as the maximum displacement component in scaling the displacements for all subcases. Each subcase is separately scaled according to its own maximum if this item is absent.

5. SET - Integer following identifies a set which defines the portion of the structure to be plotted. Default is first set defined.

6. ØRIGIN - Integer following identifies the origin to be used for the plot. Default is first origin defined.

7. SYMMETRY w - Prepare an undeformed or deformed plot of the symmetric portion of the object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k, and will appear as a reflection about the plane whose normal is oriented parallel to the coordinate direction w.

   ANTISYMMETRY w - Prepare a deformed plot of the symmetric portion of the antisymmetrically loaded object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k,

and will appear as a reflection of the antisymmetrically deformed structure about the plane whose normal is oriented parallel to the coordinate direction w.

The symbol w may specify the basic coordinates X, Y, or Z or any combination thereof. This option allows the plotting of symmetric and/or antisymmetric combinations, provided that an origin is selected for the portion of the structure defined by the bulk data that allows sufficient room for the complete plot. This does not permit the combination of symmetric and antisymmetric subcases, as each plot must represent a single subcase. In the case of a double reflection the figure will appear as one reflected about the plane whose normal is parallel to the first of the coordinates w, followed by a reflection about the plane whose normal is oriented parallel to the second of the coordinates w. This capability is primarily used in the plotting of structures that are loaded in a symmetric or an antisymmetric manner.

8. PEN - Integer following controls the internal NASTRAN pen number (see table in Section 4.2.2.2) that is used to generate the plot on table plotters.

   DENSITY - Integer following specifies line density for film plotters. A line density of d is d times heavier than a line density of 1.

9. SYMBØLS m[,n] - All of the grid points associated with the specified set will have symbol m overprinted with symbol n printed at its location. If n is not specified, only symbol m will be printed.

   Following is a table of symbols available on each plotter. Symbols that are not available on a given plotter are defaulted to a similar symbol indicated in parentheses.

SYMBØL NØ. m or n	SYMBØL	AVAILABILITY		
		EAI 3500	SC4020	All Others
0	no symbol	X	X	X
1	X	X	X	X
2	*	X	X	X
3	+	X	X	X
4	-	X	X	X
5	•	X	X	X
6	○	X	X	X
7	□	X	X	X
8	◇	X	(7)	X
9	△	(7)	(7)	X

10. LABEL GRID PØINTS - All the grid points associated with the specified set have their identification number printed to the right of the undeflected or deflected location (undeflected location in the case of superimposed plots).

    LABEL ELEMENTS - All the elements included in the specified set are identified by the element identification number and type at the center of each element. (Undeflected location in the case of superimposed plots).

    LABEL BØTH - Label both the grid points and elements.

    Labels for element types are given in the following table:

Element Type	Label
BAR	BR
CØNRØD	CR
QDMEM	QM
QDMEM1	QM
QDMEM2	QM
QDPLT	QP
QUAD1	Q1
QUAD2	Q2
RØD	RD
SHEAR	SH
TRBSC	TB
TRIA1	T1
TRIA2	T2
TRIMEM	TM
TRPLT	TP
TUBE	TU
TWIST	TW
VISC	VS
PLØTEL	PL

11. SHAPE - All the elements included in the specified set are shown by connecting the associated grid points in a predetermined manner.

    Both deformed and undeformed shapes may be specified. All of the deformed shapes relating to the subcases listed after DEFØRMATIØN may be underlaid on each of their plots by including "0" with the subcase sring after DEFØRMATIØN on the PLØT card. The undeformed plot will be drawn using PEN 1 or DENSITY 1 and symbol 2 (if SYMBØLS is specified).

12. VECTØR v - A line will be plotted at the grid points of the set, representing in length and direction the deformation of the point.

    Vectors representing the total deformation or its principal components may be plotted by insertion of the proper letter(s) for variable v. Possible vector combinations are:

    X or Y or Z - requesting individual components

    XY or XZ or YZ - requesting 2 specified components

    XYZ - requesting all 3 components

    RXY or RXZ or RYZ - requesting vector sum of 2 components

    R - requesting total vector deformation

    N - used with any of the above combinations to request no underlay shape be drawn.

    All plots requesting the VECTØR option shall have an underlay generated of the undeformed shape using the same sets, "PEN 1" or "DENSITY 1", and symbol 2 (if SYMBØLS is specified). If "SHAPE" and "VECTØR" are specified; the underlay will depend on whether "0" is used with DEFØRMATIØN. It will be the deformed shape when not used and will be both deformed and undeformed shapes when it is used. The part of the vector at the grid point will be the tail when the underlay is undeformed and the head when it is deformed. If the "N" parameter is used no shape will be drawn but other options such as SYMBØLS will still be valid.

Examples of PLØT Cards

1. PLØT

   Undeformed SHAPE using first defined SET, first defined ØRIGIN and PEN 1 (or DENSITY 1).

2. PLØT SET 3 ØRIGIN 4 PEN 2 SHAPE SYMBØLS 3 LABEL

   Undeformed SHAPE using SET 3, ØRIGIN 4, PEN 2 (or DENSITY 2) with each grid point of the set having a + placed at its location, and its identification number printed adjacent to it.

3. PLØT MØDAL DEFØRMATIØN 5 SHAPE

   Modal deformations as defined in subcase 5 using first defined SET, first defined ØRIGIN, and PEN 1 (or DENSITY 1).

4. PLØT STATIC DEFØRMATIØN 0, 3 THRU 5, 8 PEN 4, SHAPE

   STATIC deformations as defined in subcases 3, 4, 5 and 8, deformed SHAPE; drawn with PEN 4, using first defined SET and ØRIGIN, underlayed with undeformed SHAPE drawn with PEN 1. This command will cause four plots to be generated.

5. PLØT STATIC DEFØRMATIØN 0 THRU 5,

   SET 2 ØRIGIN 3 PEN 3 SHAPE,

   SET 2 ØRIGIN 4 PEN 4 VECTØRS XYZ SYMBØLS 6,

   SET 35 SHAPE

   Deformations as defined in subcases 1, 2, 3, 4, and 5, undeformed underlay with PEN 1, consisting of SET 2 at ØRIGIN 3, SET 2 at ØRIGIN 4 (with an * placed at each grid point location), and SET 35 at ØRIGIN 4. Deflected data as follows: SHAPE using SET 2 at ØRIGIN 3 (PEN 3) and SET 35 at ØRIGIN 4 (PEN 4); 3 VECTØRS (X, Y and Z) drawn at each grid point of SET 2 at ØRIGIN 4 (PEN 4) (less any excluded grid points), with O placed at the end of each vector.

6. PLØT STATIC DEFØRMATIØNS 0, 3, 4,

   SET 1 ØRIGIN 2 DENSITY 3 SHAPE,

   SET 1 SYMMETRY Z SHAPE,

   SET 2 ØRIGIN 3 SHAPE,

   SET 2 SYMMETRY Z SHAPE

   Static deformations as defined in subcases 3 and 4, both halves of a problem solved by symmetry using the X-Y principal plane as the plane of symmetry. SET 1 at ØRIGIN 2 and SET 2 at ØRIGIN 3, with the deformed shape plotted using DENSITY 3 and the undeformed structure plotted using DENSITY 1. The deformations of the "opposite" half will be plotted to correspond to symmetric loading. This command will cause two plots to be generated.

7. PLØT TRANSIENT DEFØRMATIØN 1, TIME 0.1, 0.2, MAXIMUM DEFØRMATIØN 2.0, SET 1, ØRIGIN 1,

   PEN 2, SYMBØLS 2, VECTØR R

   Transient deformations as defined in subcase 1 for time = 0.1 to time = 0.2, using set 1 at origin 1. The undeformed shape using pen or density 1 with an * at each grid point location will be drawn as an underlay for the resultant deformation vectors using pen or density 2 with an * typed at the end of each vector drawn. In addition a plotted value of 2.0 will be used for the single maximum deformation occuring on any of the plots produced. All other deformations on all other plots will be scaled relative to this single maximum deformation. This command will cause a plot to be generated for each output time step which lies between 0.1 and 0.2.

4.2.3 Summary of Structure Plot Request Packet Cards

SET Definition - Required

SET i [INCLUDE][ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5, etc.

$\left[\begin{array}{l}\text{INCLUDE}\\ \text{EXCLUDE}\\ \text{EXCEPT}\end{array}\right]\left[\begin{array}{l}\text{ELEMENTS}\\ \text{GRID PØINTS}\end{array}\right]$ k_1, k_2, k_3 THRU k_4, k_5, etc.

Parameter Definition - Optional, except as noted

PLØTTER plotter name, MØDEL name $\left[\text{DENSITY}\left\{\begin{array}{c}800\\ 556\\ 200\end{array}\right\}\text{BPI}\right]$ (Required if not SC-4020)

$\left\{\begin{array}{l}\text{ØRTHØGRAPHIC}\\ \text{PERSPECTIVE}\\ \text{STEREØSCØPIC}\end{array}\right\}$ PRØJECTIØN

AXES r, s, t $\left[\left\{\begin{array}{l}\text{SYMMETRIC}\\ \text{ANTISYMMETRIC}\end{array}\right\}\right]$

VIEW γ, β, α

SCALE a[, b] (Required if not on FIND card)

ØRIGIN i, u, v (Required if not on FIND card)

VANTAGE PØINT r_o, s_o, t_o[, s_{or}] (Required for perspective and steroscopic projections if not on FIND card)

PRØJECTIØN PLANE SEPARATIØN d_o (Required for perspective and steroscopic projections if VANTAGE PØINT not on FIND card)

ØCULAR SEPARATIØN os

MAXIMUM DEFØRMATIØN d (Required if deformed shapes are to be drawn)

PEN i[, SIZE j][, CØLØR name]

```
CAMERA type [,BLANK FRAMES n]
```

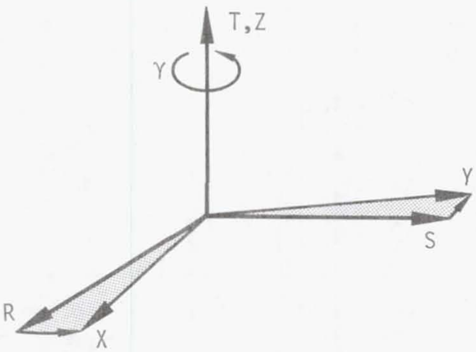
```
PAPER SIZE  a {X } b, TYPE name
              {BY}
```

FIND Card - Optional

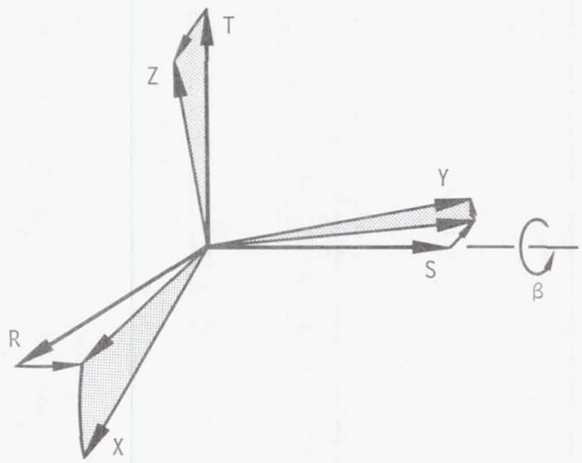
```
FIND [SCALE],[ØRIGIN i],[VANTAGE PØINT],[SET j], [REGIØN le, be, re, te]
```

PLØT Execution Card - Required

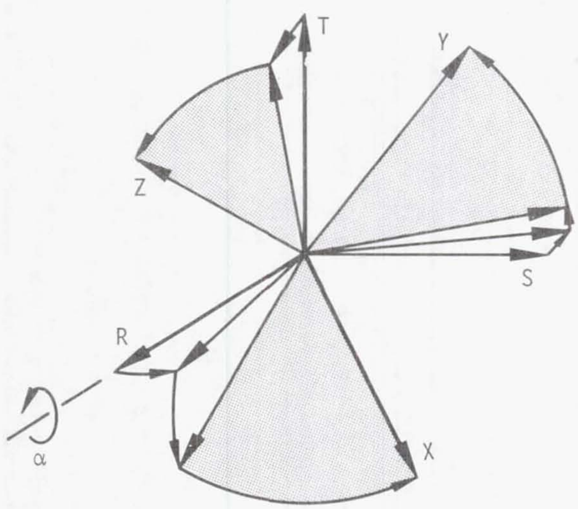
```
     [(STATIC   )                                   ] [{RANGE λ1, λ2}]
PLØT [{MØDAL    } DEFØRMATIØN i1, i2 THRU i3, i4, etc.] [{TIME  t1, t2}] [MAXIMUM DEFØRMATIØN d],
     [(TRANSIENT)                                   ]

                   [{SYMMETRY    }  ] [{PEN    }  ]                     [       (GRID PØINTS)]
[SET j1][ØRIGIN k1][{ANTISYMMETRY} w] [{DENSITY} p] [SYMBØLS m[, n]] [LABEL {ELEMENTS   }] ,
                                                                    [       (BØTH       )]
[SHAPE          ]
[VECTØR v       ] ,
[SHAPE, VECTØR v]
[SET j2][ØRIGIN k2] .... etc.
```



(a) γ - rotation about T-axis.



(b) β — rotation about S-axis



(c) α - rotation about R-axis

Figure 1. Plotter coordinate system-model orientation.

4.3 X-Y ØUTPUT

In rigid formats used for transient response and frequency response (including random response), the amount of output data generated is voluminous. In order to aid the user in assimilating this vast amount of data, the X-Y output processing modules XYTRAN and XYPLØT have been provided. The primary purpose of these modules is to generate plotted graphs of y(x) where x is frequency or time and y is any response quantity selected by the user for observation. The user is not required to specify any parametric data for the X-Y plotter; however, he may do so if he wishes in order to obtain desired scales, regions of observation, etc.

In addition to (or in place of) the plots, X-Y tabular output may be printed or punched, and summary data (e.g., maximum and minimum values and locations of these values) may be obtained for any X-Y output.

The X-Y output described above is obtained by the user via the X-Y output request packet of the Case Control Deck. This packet includes all cards between ØUTPUT(XYPLØT) [or ØUTPUT(XYØUT)] and either BEGIN BULK or ØUTPUT(PLØT). The remainder of this section describes the X-Y output request data cards and the rules for writing them. Examples are provided to illustrate the use of this feature.

4.3.1 <u>X-Y Plotter Terminology</u>

A single set of plotted X-Y pairs is known as a "curve". Curves are the entities that the user requests to be plotted. The surface (paper, microfilm frame, etc.) on which one or more curves is plotted is known as a "frame". Curves may be plotted on a whole frame, an upper half frame, or a lower half frame. Grid lines, tic marks, axes, axis labeling and other graphic control items may be chosen by the user. The program will select defaults for parameters not selected by the user.

Only three cards are required for an X-Y plot request. The required cards are:

1. X-Y output request packet identifier - ØUTPUT(XYPLØT) or ØUTPUT(XYØUT).
2. Plotter selection card.
3. At least one command operation card.

The terms ØUTPUT(XYPLØT) and ØUTPUT(XYØUT) are interchangeable and either form may be used for any of the X-Y output requests. The plotter selection card is described as item 1 in Section 4.3.2.1.

If the output is limited to printing and/or punching the plotter selection card is not required. The command operation card is used to request the various forms of X-Y output. This card is described in Section 4.3.3.

If only the required cards are used, the graphic control items will all assume default values. Curves using all default parameters have the following general characteristics:

1. Tic marks are drawn on all edges of the frame. Five spaces are provided on each edge of the frame.
2. All tic marks are labeled with their values.
3. Linear scales are used.
4. Scales are selected such that all points fall within the frame.
5. The plotted points are connected with straight lines.
6. The plotted points are not identified with symbols.

The above characteristics may be modified by inserting any of the parameter definition cards, described in Section 4.3.2, ahead of the command operation card or cards. The use of a parameter definition card sets the value of that parameter for all following command operation cards unless the CLEAR card is inserted (see item 16 of Section 4.3.2.1). If grid lines are requested, they will be drawn at the locations of all tic marks that result from defaults or user request. The locations of tic marks (or grid lines) for logarithmic scales cannot be selected by the user. Default values for logarithmic spacing are selected by the program. The default values for the number of tic marks (or grid lines) per cycle depend on the number of logarithmic cycles required for the range of the plotted values.

The definition and rules for the X-Y output request packet cards follow. The definition notation used in Section 4.2.1.2 will also be followed here. The form of statements used in the X-Y output request packet differs in many instances from that of similar cards used in the structure plotter request packet. The user is cautioned to prepare his input decks as specified herein.

4.3.2 Parameter Definition Cards

4.3.2.1 Cards Pertaining to All Curves

1. PLØTTER = plotter name, model name

   Selects plotter; required if plots are requested. Plotter choices are listed in Section 4.1. (Note: one or both of the plot tapes must be set up. See Section 5 of the Programmer's Manual for instructions.)

2. CAMERA = c (Integer)

   Used for microfilm plotters only to select camera as follows: $c \leq 1$ for film, $c = 2$ for paper, $c \geq 3$ for both; default value is 3.

3. PENSIZE = ps (Integer ≥ 0)

   Used to select pen for table plotter; default value is 1. (See Section 4.2.2.2)

4. DENSITY = d (Integer ≥ 0)

   Used to select line density for microfilm plotters only; default value is 1. A line density of d is d times heavier than a line density of 1.

5. SKIP = s (Integer ≥ 0)

   Used to insert blank frames between requested frames for microfilm plotters; default value is 1.

6. XPAPER = x (Real)
   YPAPER = y (Real)

   Defines paper size for table plotters; default value is x = 8.5 inches and y = 11.0 inches.

7. XMIN = x1 (Real)
   XMAX = x2 (Real)

   Specifies limits of abscissa of curve; default values are chosen so as to accommodate all points.

8. XLØG = $\left\{ \begin{matrix} \text{YES} \\ \text{NØ} \end{matrix} \right\}$

   Request for logarithmic x-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table at end of this Section).

9. YAXIS = $\left\{ \begin{matrix} \text{YES} \\ \text{NØ} \end{matrix} \right\}$

   Request for plotting y-axis; default value is NØ.

10. XINTERCEPT = xi (Real)

    Location on the x-axis where the y-axis will be drawn; default value is 0.0.

11. UPPER TICS = ut (Integer*)

    Request for tick marks to be drawn on the upper edge of the frame; default value is integer one.

12. LØWER TICS = lt (Integer*)

    Request for tic marks to be drawn on the lower edge of the frame; default value is integer one.

13. CURVELINESYMBØL = cls (Integer)

    Request for points to be connected by lines (cls = 0), identified by symbol |cls| (cls < 0), or both (cls > 0); default value is 0; see Section 4.2.2.3 for the list of symbols. If more than 1 curve per frame, the symbol number is incremented by 1 for each curve.

14. XDIVISIØNS = xd (Integer > 0)

    Applies xd uniform spaces along the x-direction for whichever of the following are callec for: UPPER TICS, LØWER TICS, YINTERCEPT: default value is 5 spaces, not applicable to log scales.

15. XVALUE PRINT SKIP = xps (Integer $\geq$ 0)

    Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is xps.

16. CLEAR

    Causes all parameter values except PLØTTER and titles (XTITLE, YTITLE, YTTITLE, YBTITLE, TCURVE) to revert to their default values.

17. XTITLE = {any legitimate character string}

    Title to be used with x-axis.

18. TCURVE = {any legitimate character string}

    Curve title.

The default values for tic divisions on log plots are given in the following table, but will range over whole cycles:

Number of Cycles	Intermediate Values
1, 2	2., 3., 4., 5., 6., 7., 8., 9.
3	2., 3., 5., 7., 9.
4	2., 4., 6., 8.
5	2., 5., 8.
6, 7	3., 6.
8, 9, 10	3.

4.3.2.2 Cards Pertaining Only to Whole Frame Curves

1. YMIN = y1 (Real)
   YMAX = y2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

*See note on page 4.3-8.

2. XAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YINTERCEPT = yi (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate; default value is NØ. Default value for tic division interval depends on number of log cycles (see Section 4.3.2.1).

5. LEFT TICS = lt (Integer*)

   Request for tic marks to be drawn on the left edge of the frame; default value is integer one.

6. RIGHT TICS = rt (Integer*)

   Request for tic marks to be drawn on the right edge of the frame; default value is integer one.

7. ALLEDGE TICS = aet (Integer*)

   Request for tic marks to be drawn on all edges of the frame; default value is zero.

8. YDIVISIØNS = yd (Integer > 0)

   Applies yd uniform spaces along the y-direction for whichever of the following are called for: LEFT TICS, RIGHT TICS, XINTERCEPT; default value is 5 spaces; not applicable to log scales.

9. YVALUE PRINT SKIP = yps (Integer ≥ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is yps.

10. XGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

11. YGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YTITLE = {any legitimate character string}

    Title to be used with y-axis.

4.3.2.3 Cards Pertaining <u>Only</u> to Upper Half Frame Curves

1. YTMIN = yt1 (Real)
   YTMAX = yt2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

* See note on page 4.3-8.

2. XTAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YTINTERCEPT = yti (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YTLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. TLEFT TICS = tlt (Integer*)

   Request for tic marks to be drawn on the left edge of the upper half frame; default value is integer one.

6. TRIGHT TICS = trt (Integer*)

   Request for tic marks to be drawn on the right edge of the upper half frame; default value is integer one.

7. TALL EDGE TICS = taet (Integer*)

   Request for tic marks to be drawn on all edges of the upper half frame; default value is zero.

8. YTDIVISIØNS = ytd (Integer > 0)

   y-direction tic divisions; default value is 5 spaces; not applicable to log scales.

9. YTVALUE PRINT SKIP = ytps (Integer ≥ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ytps.

10. XTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

11. YTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YTTITLE = {any legitimate character string}

    Title to be used with y-axis.

* See note on page 4.3-8.

4.3.2.4 Cards Pertaining Only to Lower Half Frame Curves

1. YBMIN = yb1 (Real)
   YBMAX = yb2 (Real)

   Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

2. XBAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YBINTERCEPT = ybi (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YBLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

   Request for logarithmic y-coordinate, default value is NØ; default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. BLEFT TICS = blt (Integer*)

   Request for tic marks to be drawn on the left edge of the lower half frame; default value is integer one.

6. BRIGHT TICS = brt (Integer*)

   Request for tic marks to be drawn on the right edge of the lower half frame; default value is integer one.

7. BALL EDGE TICS = baet (Integer*)

   Request for tic to be drawn on all edges of the lower half frame; default value is zero.

8. YBDIVISIØNS = ybd (Integer > 0)

   y-direction tic divisions; default value is 5 spaces; not applicable to log scales.

9. YBVALUE PRINT SKIP = ybps (Integer $\geq$ 0)

   Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ybps.

10. XBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

* See note on page 4.3-8.

11. YBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YBTITLE = any legitimate character string

Title to be used with y-axis.

* Note

To determine if on any given edge (a) tic marks will be drawn without values, (b) no tic marks or values will be drawn or (c) tic marks with values will be drawn, the following sum must be computed by the user. Add the tic integer value of the edge in question to its associated ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS integer value. If the resulting value is less than 0, tic marks will be drawn without values. If the resulting value is 0, no tic marks or values will be drawn. If the resulting value is greater than 0, tic marks with values will be drawn. The user should be "careful" in his use of the ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS cards. For example, the use of only the ALLEDGE TICS = -1 card will result in no tic marks or values being drawn since the default values for individual edges is + 1. Tic values input may only be -1,0, or 1.

4.3.3 Command Operation Cards

When a command operation is encountered, one or more frames will be generated using the current parameter specifications. The form of this card is:

Operation 1 or more (required)	Curve Type 1 only (required)	Plot Type	Subcase List	Curve Request(s)
XYPLØT XYPRINT XYPUNCH XYPEAK XYPAPLØT	ACCE DISP ELFØRCE NØNLINEAR ØLØAD SACCE SDISP SPCF STRESS SVELØ VECTØR VELØ	RESPØNSE AUTØ PSDF	i_1, i_2, i_3, i_4 THRU i_5, i_6, etc. default is all subcases	"frames"

Operation - The entries in the Operation field have the following meaning:

1. XYPLØT - generate X-Y plots for the selected plotter.
2. XYPRINT - generate tabular printer output for the X-Y pairs.
3. XYPUNCH - generate punched card output for the X-Y pairs. Each card contains the following information:
    1. X-Y pair sequence number
    2. X-value
    3. Y-value
    4. Card sequence number
4. XYPEAK - output is limited to the printed summary page for each curve. This summary page contains the maximum and minimum values of y for the range of x.
5. XYPAPLØT - generate X-Y plots on the printer. The X axis moves horizontally along the page and the Y axis moves vertically along the page. Symbol '*' identifies the points associated with the first curve of a frame, then for successive curves on a frame the points are designated by symbols 'O', 'A', 'B', 'C', 'D', 'E', 'F', 'G' and 'H'.

Curve Type - The entries in the curve type field have the meaning given below. Only one may appear in a single command operation logical card. However, there is no limit to the number of such cards.

Curve Type	Meaning
ACCE	Acceleration in the physical set
DISP	Displacement in the physical set
ELFØRCE	Element Force
NØNLINEAR	Nonlinear load
ØLØAD	Load
SACCE	Acceleration in the solution set
SDISP	Displacement in the solution set
SPCF	Single-point force of constraint
STRESS	Element stress
SVELØ	Velocity in the solution set
VECTØR	Displacement in the physical set
VELØ	Velocity in the physical set

Solution set requests are more efficient, as the time-consuming recovery of the dependent displacements can be avoided. If there is a request for STRESS or ELFØRCE, the recovery of dependent displacements cannot be avoided.

Plot Type - The entries in the Plot Type field have the following meanings:

1. RESPØNSE - generate frequency response or transient response output. This is the default value.
2. AUTØ - generate output for the autocorrelation function.
3. PSDF - generate output for the power spectral density function.

Subcase List - Generate output for the subcase numbers that are listed. Default is all subcases for which solutions were obtained. The subcase list must be in ascending order.

Curve Request(s) - The word "frames" represents a series of curve identifiers of the following general form:

/a1(b1,c1),a2(b2,c2),etc./d1(e1,f1),d2(e2,f2),etc./etc.

The information between slashes (/) specifies curves that are to be drawn on the same frame. The symbol a1 identifies the grid point or element number associated with the first plot on the first frame. The symbol a2 identifies the grid point or element number associated with the second plot on the first frame. The symbols d1 and d2 identify similar items for plots on the second frame, etc. Symbols are assigned in order by grid point or element identification number.

The symbols b1 and b2 are codes for the items to be plotted on the upper half of the first frame, and c1 and c2 are codes for the items to be plotted on the lower half of the first frame. If any of the symbols b1, c1, b2, or c2 are missing, the corresponding curve is not generated. If the comma (,) and c1 are absent along with the comma (,) and c2, full frame plots will be prepared on the first frame for the items represented by b1 and b2. For any single frame, curve identifiers must be all of the whole frame type or all of the half frame type, i.e., the comma (,) following b1 and b2 must be present for all entries or absent for all entries in a single frame. The symbols e1, f1, e2, and f2 serve a similar purpose for the second frame, etc. If continuation cards are needed the previous card may be terminated with any one of the slashes (/) or commas (,) in the general format.

The manner in which the item code (e.g., b1, b2) is implemented is dependent upon whether the Plot Type is either (a) RESPØNSE or (b) AUTØ or PSDF.

Plot Type RESPØNSE

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3, T1RM, T2RM, T3RM, R1RM, R2RM, R3RM, T1IP, T2IP, T3IP, R1IP, R2IP, or R3IP, where Ti stands for the i^{th} translational component, Ri stands for the i^{th} rotational component, and RM means real or magnitude and IP means imaginary or phase. For scalar or extra points, use T1, T1RM, or T1IP. For elements use a positive integer from the following tables for element stress item codes or element force item codes. See Section 1.3 for interpretation of symbols.

Plot Types AUTØ or PSDF

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3; for scalar or extra points use T1. The symbols T1, T2, T3, R1, R2, R3 are defined as above. For elements use a positive integer from the following tables noting that if an item has a real and imaginary part, the selection of either part will result in the use of both parts. Real numbers will be treated as if they are complex numbers with zero imaginary parts. Split frames cannot be used for AUTØ or PSDF plots.

Element Stress Item Codes

(All items are stresses unless otherwise denoted)

Element Name	Real Element Stresses: Item Code	Real Element Stresses: Item	Complex Element Stresses: Item Code	Complex Element Stresses: Item	Real-Mag. or Imag.-Phase
RØD	2	Axial Stress	2	Axial Stress	RM
	3	Axial Safety Margin	3	Axial Stress	IP
	4	Torsional Stress	4	Torsional Stress	RM
	5	Torsional Safety Margin	5	Torsional Stress	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Maximum Shear	2	Maximum Shear	RM
	3	Average Shear	3	Maximum Shear	IP
	4	Safety Margin	4	Average Shear	RM
			5	Average Shear	IP
TWIST	2	Maximum	2	Maximum	RM
	3	Average	3	Maximum	IP
	4	Safety Margin	4	Average	RM
			5	Average	IP
TRIA1		Z1 = Fibre Distance 1		Z1 = Fibre Distance 1	
	3	Normal-x at Z1	3	Normal-x at 1	RM
	4	Normal-y at Z1	4	Normal-x at 1	IP
	5	Shear-xy at Z1	5	Normal-y at 1	RM
	6	θ-Shear Angle at Z1	6	Normal-y at 1	IP
	7	Major-Principal at Z1	7	Shear-xy at 1	RM
	8	Minor-Principal at Z1	8	Shear-xy at 1	IP
	9	Max-Shear at Z1		Z2 = Fibre Distance 2	
		Z2 = Fibre Distance 2	10	Normal-x at 2	RM
	11	Normal-x at Z2	11	Normal-x at 2	IP
	12	Normal-y at Z2	12	Normal-y at 2	RM
	13	Shear-xy at Z2	13	Normal-y at 2	IP
	14	θ-Shear Angle at Z2	14	Shear-xy at 2	RM
	15	Major-Principal at Z2	15	Shear-xy at 2	IP
	16	Minor-Principal at Z2			
	17	Maximum-Shear at Z2			
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
TRMEM	2	Normal-x	2	Normal-x	RM
	3	Normal-y	3	Normal-x	IP
	4	Shear-xy	4	Normal-y	RM
	5	θ-Shear Angle	5	Normal-y	IP
	6	Major-Principal	6	Shear-xy	RM
	7	Minor-Principal	7	Shear-xy	IP
	8	Maximum Shear			
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Stress	2	Stress	RM
			3	Stress	IP
ELAS2	2	Stress	2	Stress	RM
			3	Stress	IP

Element Name	Item Code	Real Element Stresses Item	Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
ELAS3	2	Stress	2	Stress	RM
			3	Stress	IP
QDPLT		Same as TRIA1		Same as TRIA1	
QDMEM		Same as TRMEM		Same as TRMEM	
QDMEM1		Same as TRMEM		Same as TRMEM	
QDMEM2		Same as TRMEM		Same as TRMEM	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	
QUAD1		Same as TRIA1		Same as TRIA1	
BAR	2	SA1	2	SA1	RM
	3	SA2 *	3	SA2 *	RM
	4	SA3	4	SA3	RM
	5	SA4	5	SA4	RM
	6	Axial	6	Axial	RM
	7	SA-maximum	7	SA1	IP
	8	SA-minimum	8	SA2 *	IP
	9	Safety Margin in Tension	9	SA3	IP
	10	SB1	10	SA4	IP
	11	SB2 *	11	Axial	IP
	12	SB3	12	SB1	RM
	13	SB4	13	SB2	RM
	14	SB-maximum	14	SB3	RM
	15	SB-minimum	15	SB4 *	RM
	16	Safety Margin in Comp.	16	SB1	IP
			17	SB2	IP
			18	SB3	IP
			19	SB4	IP
CØNEAX		Z1 = Fibre Distance 1			
	4	Normal-u at 1			
	5	Normal-v at 1			
	6	Shear-uv at 1			
	7	θ-Shear Angle at 1			
	8	Major-Principal at 1			
	9	Minor-Principal at 1			
	10	Maximum Shear at 1			
		Z2 = Fibre Distance 2			
	12	Normal-u at 2			
	13	Normal-v at 2			
	14	Shear-uv at 2			
	15	θ-Shear Angle at 2			
	16	Major-Principal at 2			
	17	Minor-Principal at 2			
	18	Maximum Shear at 2			
TRIARG	2	Radial (x)			
	3	Circum. (Theta)			
	4	Axial (z)			
	5	Shear (zx)			

*See footnote 2 on next page.

Element Name	Item Code	Real Element Stresses Item	Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
TRAPRG	2	Radial (x) at 1			
	3	Circum. (Theta) at 1			
	4	Axial (z) at 1			
	5	Shear (zx) at 1			
	6	Radial (x) at 2			
	7	Circum. (Theta) at 2			
	8	Axial (z) at 2			
	9	Shear (zx) at 2			
	10	Radial (x) at 3			
	11	Circum. (Theta) at 3			
	12	Axial (z) at 3			
	13	Shear (zx) at 3			
	14	Radial (x) at 4			
	15	Circum. (Theta) at 4			
	16	Axial (z) at 4			
	17	Shear (zx) at 4			
	18	Radial (x) at 5			
	19	Circum. (Theta) at 5			
	20	Axial (z) at 5			
	21	Shear (zx) at 5			
TØRDRG	2	Mem.-Tangen. at 1			
	3	Mem.-Circum. at 1			
	4	Flex.-Tangen. at 1			
	5	Flex.-Circum. at 1			
	6	Shear-Force at 1			
	7	Mem.-Tangen. at 2			
	8	Mem.-Circum. at 2			
	9	Flex.-Tangen. at 2			
	10	Flex.-Circum. at 2			
	11	Shear-Force at 2			
	12	Mem.-Tangen. at 3			
	13	Mem.-Circum. at 3			
	14	Flex.-Tangen. at 3			
	15	Flex.-Circum. at 3			
	16	Shear-Force at 3			

Note:

1. If output is magnitude/phase the magnitude replaces the real part and the phase replaces the imaginary part.

2. The symbols SA1,2,3,4 and SB1,2,3,4 stand for stresses on end A or B at locations C, D, E, and F respectively as defined on the first continuation card of the PBAR bulk data card.

Element Force Item Codes

(All items are element forces (or moments) unless otherwise indicated)

Element Name	Real Element Forces Item Code	Real Element Forces Item	Complex Element Forces Item Code	Complex Element Forces Item	Real-Mag. or Imag.-Phase
RØD	2	Axial Force	2	Axial Force	RM
	3	Torque	3	Axial Force	IP
			4	Torque	RM
			5	Torque	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Force Pts. 1, 3	2	Force Pts. 1, 3	RM
	3	Force Pts. 2, 4	3	Force Pts. 1, 3	IP
			4	Force Pts. 2, 4	RM
			5	Force Pts. 2, 4	IP
TWIST	2	Moment Pts. 1, 3	2	Moment Pts. 1, 3	RM
	3	Moment Pts. 2, 4	3	Moment Pts. 1, 3	IP
			4	Moment Pts. 2, 4	RM
			5	Moment Pts. 2, 4	IP
TRIA1	2	Bend-Moment-x	2	Bend-Moment-x	RM
	3	Bend-Moment-y	3	Bend-Moment-y	RM
	4	Twist-Moment	4	Twist-Moment	RM
	5	Shear-x	5	Shear-x	RM
	6	Shear-y	6	Shear-y	RM
			7	Bend-Moment-x	IP
			8	Bend-Moment-y	IP
			9	Twist-Moment	IP
			10	Shear-x	IP
			11	Shear-y	IP
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Force	2	Force	RM
			3	Force	IP
ELAS2	2	Force	2	Force	RM
			3	Force	IP
ELAS3	2	Force	2	Force	RM
			3	Force	IP
ELAS4	2	Force	2	Force	RM
			3	Force	IP
QDPLT		Same as TRIA1		Same as TRIA1	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	

Element Name	Real Element Forces Item Code	Real Element Forces Item		Complex Element Forces Item Code	Complex Element Forces Item		Real-Mag. or Imag.-Phase
QUAD1		Same as TRIA1			Same as TRIA1		
BAR	2	Bend-Moment	A1	2	Bend-Moment	A1	RM
	3	Bend-Moment	A2	3	Bend-Moment	A2	RM
	4	Bend-Moment	B1	4	Bend-Moment	B1	RM
	5	Bend-Moment	B2	5	Bend-Moment	B2	RM
	6	Shear-1		6	Shear-1		RM
	7	Shear-2		7	Shear-2		RM
	8	Axial Force		8	Axial Force		RM
	9	Torque		9	Torque		RM
				10	Bend-Moment	A1	IP
				11	Bend-Moment	A2	IP
				12	Bend-Moment	B1	IP
				13	Bend-Moment	B2	IP
				14	Shear-1		IP
				15	Shear-2		IP
				16	Axial Force		IP
				17	Torque		IP

4.3.4 Examples of X-Y Output Request Packets

BEGIN BULK or ØUTPUT(PLØT) card is shown as a reminder to the user to place his X-Y output request packet properly in his Case Control Deck, i.e., at the end of the Case Control Deck or just ahead of any structure plot requests.

Example 1

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
XYPLØT SDISP / 16(T1)
BEGIN BULK
```

Causes a single whole frame to be plotted for the T1 displacement component of solution set point 16 using the default parameter values. If 16(T1) is not in the solution set, a warning message will be printed and no plot will be made. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 2

```
ØUTPUT(XYØUT)
PLØTTER =EAI 3500
XYPLØT, XYPRINT VELØ RESPØNSE 1,5 / 3(R1, ), 5( ,R1)
ØUTPUT(PLØT)
```

Causes a single frame (consisting of an upper half frame and a lower half frame) to be plotted using the default parameter values. The velocity of the first rotational component of grid point 3 will be plotted on the upper half frame and that of grid point 5 will be plotted on the lower half frame for subcases 1 and 5. Tabular printer output will also be generated for both curves. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up. Scales will be selected such that the frame will fit on 8 1/2 x 11-inch paper.

Example 3

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
YDIVISIØNS = 20
XDIVISIØNS = 10
XGRID LINES = YES
YGRID LINES = YES
XYPLØT DISP 2,5 /10(T1),10(T3)
```

Causes two whole frame plots to be generated, one for subcase 2 and one for subcase 5. Each

plot contains the T1 and T3 displacement component for grid point 10. The default parameters will be modified to include grid lines in both the x and y-directions with 10 spaces in the x-direction and 20 spaces in the y-direction. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 4

```
ØUTPUT(XYPLØT)
PLØTTER = EAI 3500
XAXIS = YES
YAXIS = YES
XPAPER = 17.0
YPAPER = 22.0
XYPLØT STRESS 3/ 15(2)/ 21(6)
```

Causes two whole frame plots to be generated using the results from subcase 3. The first plot is the response of the axial stress for rod element number 15. The second plot is the response of the major principal stress for triangular membrane element number 21. The default parameters will be modified to include the x-axis and y-axis drawn through the origin. Each plot will be scaled to fit on 17 x 22-inch paper. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up.

4.3.5 <u>Summary of X-Y Output Request Packet Cards</u>

Type of value: I = Integer, R = Real, B = BCD. See Sections 4.3.2 and 4.3.3 for details of these cards.

Items pertaining to all plots

1.	PLØTTER	= p	-
2.	CAMERA	= c	(I)
3.	PENSIZE	= ps	(I)
4.	DENSITY	= d	(I)
5.	SKIP	= s	(I)
6.	XPAPER	= x	(R)
	YPAPER	= y	(R)
7.	XMIN	= x1	(R)
	XMAX	= x2	(R)
8.	XLØG	= yesno*	(B)
9.	YAXIS	= yesno*	(B)
10.	XINTERCEPT	= xi	(R)
11.	UPPER TICS	= ut	(I)
12.	LØWER TICS	= lt	(I)
13.	CURVLINESYMBØL	= cls	(I)
14.	XDIVISIØNS	= xd	(I)
15.	XVALUE PRINT SKIP	= xps	(I)
16.	CLEAR		-
17.	XTITLE	= {anything}	-
18.	TCURVE	= {anything}	-

	Whole frames only	Upper half frames only	Lower half frames only	
1	YMIN = y1	YTMIN = yt1	YBMIN = yb1	(R)
	YMAX = y2	YTMAX = yt2	YBMAX = yb2	(R)
2	XAXIS = yesno*	XTAXIS = yesno*	XBAXIS = yesno*	(B)
3	YINTERCEPT = yi	YTINTERCEPT = yti	YBINTERCEPT = ybi	(I)
4	YLØG = yesno*	YTLØG = yesno*	YBLØG = yesno*	(B)
5	LEFT TICS = lt	TLEFT TICS = tlt	BLEFT TICS = blt	(I)
6	RIGHT TICS = rt	TRIGHT TICS = trt	BRIGHT TICS = brt	(I)
7	ALLEDGE TICS = aet	TALL EDGE TICS = taet	BALL EDGE TICS = baet	(I)
8	YDIVISIØNS = yd	YTDIVISIØNS = ytd	YBDIVISIØNS = ybd	(I)
9	YVALUE PRINT SKIP = yps	YTVALUE PRINT SKIP = ytps	YBVALUE PRINT SKIP = ybps	(I)
10	XGRID LINES = yesno*	XTGRID LINES = yesno*	XBGRID LINES = yesno*	(B)
11	YGRID LINES = yesno*	YTGRID LINES = yesno*	YBGRID LINES = yesno*	(B)
12	YTITLE = {anything}	YTTITLE = {anything}	YBTITLE = {anything}	-

Command operation cards

{XYPLØT, XYPRINT, XYPUNCH, XYPEAK, XYPAPLØT}	{ACCE, DISP, ELFØRCE, NØNLINEAR, ØLØAD, SACCE, SDISP, SPCF, STRESS, SVELØ, VECTØR, VELØ}	{<u>RESPØNSE</u>, <u>AUTØ</u>, PSDF}	subcases /curves

* yesno must be either YES or NØ

DIRECT MATRIX ABSTRACTION

5.1 GENERAL

In addition to using the rigid formats provided automatically by NASTRAN, the user may wish to execute a series of modules in a different manner than provided by the rigid format. Or, he may wish to perform a series of matrix operations which are not contained in any existing rigid format. If the modifications to an existing rigid format are minor, the ALTER feature described in Section 2 may be employed. Otherwise, a user-written Direct Matrix Abstraction Program (DMAP) should be used.

DMAP is the user-oriented language used by NASTRAN to solve problems. A rigid format is basically a collection of statements in this language. DMAP, like English or FØRTRAN, has many grammatical rules which must be followed to be interpretable by the NASTRAN DMAP compiler. Section 5.2 provides the user with the rules of DMAP which will allow him to understand the rigid format DMAP sequences, write ALTER packages, and construct his own DMAP sequences using the many modules contained in the NASTRAN DMAP repertoire.

Section 5.3 describes individually the many nonstructurally oriented modules contained in the NASTRAN library while Section 5.4 provides several examples of DMAP usage.

User-written modules must conform to the rules and usage conventions described herein.

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD   I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz  $

    where   MØD is the DMAP Functional Module name,
            Ii; i = 1,m are the Input Data Block names,
            Øi; i = 1,n are the Øutput Data Block names,
    and     ai,bi,pi; i = 1,z are the Parameter Sections.
```

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign ($) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

5.2.1.1 Each Functional Module DMAP statement must conform to the MPL regarding

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

5.2.1.2 *Functional Module Names*

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.3.3) or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

An input data block must be previously defined in the DMAP sequence. This is accomplished by causing the data block to be output from a previous DMAP instruction. Input File Processor outputs and any user-input (via Bulk Data Cards) DMI or DTI data block names are exempt from this rule as are data blocks existing on the Old Problem Tape. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null.

5.2.1.4 Functional Module Output Data Blocks

A data block name may appear as an output once and only once. New names may be equivalenced to old ones, however, as described in Section 5.2.3.2. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null.

5.2.1.5 Functional Module Parameters

Parameters are used for many purposes. They may convey data values into and/or out from the module, or they may simply serve as flags to control the computational flow within the module. The general form of a parameter section of a DMAP instruction is

ai,bi,pi

where the parameter specifications are:

ai =	V	Parameter value is variable and may be changed by the module during execution.
	C	Parameter value is prescribed initially by the user and is an unalterable constant.

bi =	Y	Initial parameter value may be specified on a PARAM bulk data card.
	N	Initial parameter value may not be specified on a PARAM bulk data card.

pi =	PNAME = v	PNAME is a BCD value selected by the user to represent the name of the parameter.
	PNAME	
	v	

The various forms available for pi require additional clarification. The form v means a value for the parameter and may only be used when ai=C and bi=N. The other forms will be clarified in the symbolic examples that follow. Each parameter has an initial value which is established when the DMAP sequence is complied during execution of the NASTRAN preface. The means by which initial values are established for all DMAP parameters will be explained by the symbolic examples that follow. The value used at execution time may differ from the initial value if and only if the module changes the value, if ai = "V", and the parameter name appears in a SAVE (see Section 5.3.4) instruction immediately following the module. Six parameter types are available. The proper type is specified by the Module Properties List (MPL). The types and examples of values as they would be written in DMAP are given below:

Parameter Type	Value Examples		
Integer	7	-2	0
Real	-3.6	2.4+5	0.01-3
BCD		A12	
Double-Precision		2.5D0	
Complex Single-Precision		(1.0,-1.0)	
Complex Double-Precision		(1.9D0,-4.0D1)	

Many forms of the parameter section may be used. These will be explained in some detail.

null — This is equivalent to /C,N,v where v is the MPL default value which must exist. No nonnull parameters may follow a null parameter in the DMAP statement. A null is not punched, nor is the preceding /.

/C,N,v — Constant input parameter
Examples: /C,N,0/C,N,BKL0/C,N,(1.0,-1.0)

In the three examples shown, the values 0 (integer), BLK0 (BCD) and 1.0-i1.0 (complex, single precision) are defined.

/C,Y,PNAME — Constant input parameter; MPL default value is used unless a PARAM bulk data card referencing PNAME is present. Error condition is detected if either no PARAM card is present or if no MPL default value exists.

/C,Y,PNAME=v — Constant input parameter; the value v is used unless a PARAM bulk data card referencing PNAME is present.

/V,Y,PNAME or /V,Y,PNAME=v — Variable parameter; may be input, output, or both; initial value is the first of

1. value from the most recently executed SAVE instruction, if any
2. value from PARAM bulk data card referencing PNAME will be used if present in Bulk Data Deck
3. v, if present in DMAP instruction
4. MPL default value, if any
5. 0

If a parameter is output from a functional module and if the output value is to be carried forward, a SAVE instruction must immediately follow the DMAP instruction in which the parameter is generated.

/V,N,PNAME or /V,N,PNAME=v — Variable parameter; may be input, output, or both; initial value is the first of

1. value from the most recently executed SAVE instruction, if any
2. v, if present in DMAP instruction
3. MPL default value, if any
4. 0

5.2.2 DMAP Rules for Executive Operation Instructions

Each Executive Operation statement has its own format which is generally open-ended, meaning the number of inputs, outputs, etc. is not prescribed. Executive Operation instructions or statements are divided into general categories as follows:

1. Declarative instructions FILE, BEGIN and LABEL which aid the DMAP compiler and the file allocator.

2. Instructions CHKPNT, EQUIV, PURGE and SAVE which aide the NASTRAN executive system in allocating files, interfacing between functional modules and in restarting a problem.

3. Control instructions REPT, JUMP, CØND, EXIT and END which control the order in which DMAP instructions are executed.

The rules associated with the Executive Operation instructions are distinct for each instruction and are discussed individually in Section 5.3.4.

5.2.3 Techniques and Examples of Executive Module Usage

Even though the DMAP program may be interpretable by the DMAP compiler it does not guarantee that the program will yield the desired results. Therefore this section is provided to acquaint the DMAP programmer with techniques and examples used in writing DMAP programs. In particular the instructions REPT, FILE, EQUIV, PURGE and CHKPNT will now be discussed in some detail. The DMAP module descriptions for all nonstructural modules will be found in Section 5.3.

The new DMAP user should read Section 5.3 to obtain the necessary knowledge of terminology before reading this section.

The data blocks and functional modules referenced in the following examples are fictitious and have no relationship to any real data blocks or functional modules.

A data block is described as having a status of "not generated," "generated" or "purged." A status of not generated means that the data block is available for generation by appearing as output in a functional module. A status of generated means that the data block contains data which is available for input to a subsequent module. A status of purged means that the data block cannot be generated and any functional module attempting to use this data block as input or output will be informed that the purged data block is not available for use.

5.2.3.1 The REPT and FILE Instructions (see Section 5.3.4)

The DMAP instructions bounded by the REPT instruction and the label referenced by the REPT instruction are referred to as a loop. The location referenced by the REPT is called the top of the loop. In many respects a DMAP loop is like a giant functional module since it requires inputs and generates output data blocks which usually can be handled correctly by the File Allocator (see Section 4.9 of the Programmer's Manual) without any special action by the DMAP programmer. The one exception is a data block that is not referenced outside the loop (i.e., an internal data block with respect to the loop). The file allocator considers internal data blocks as scratch data blocks to be used for the present pass through the loop but not to be saved for input at the top of the loop. Should the DMAP programmer desire to save an internal data block, he may do so by declaring the data block SAVE in the FILE instruction.

When the REPT instruction transfers control back to the top of the loop, the status of all internal data blocks is changed to "not generated" unless the internal data block is declared SAVE in a FILE instruction. Note that this rule also applies to data blocks declared APPEND (see Section 5.3.4). That is, an internal data block that is declared APPEND in a FILE instruction is not saved unless it is also declared SAVE. It should also be noted that equivalences established between internal data blocks (not declared saved) and data blocks referenced outside the loop are not carried over for the next time through the loop. The equivalence must be re-established each time through the loop. Data blocks generated by the Input File Processor are considered referenced outside of all DMAP loops.

EXAMPLE using REPT and FILE instructions.

```
               BEGIN    $
               FILE     X=SAVE / Y=APPEND,SAVE / Z=APPEND $
             ( LABEL    L1  $
             ( MØD1     B/W,Y  $
      DMAP   ( CØND     L3,PX  $
      loop   ( MØD2     A/X/V,N,PX=0  $
             ( SAVE     PX  $
             ( LABEL    L3  $
             ( MØD3     W,X,Y/Z  $
             ( REPT     L1,1  $
               MØD4     Z//  $
               END      $
```

Assume that MØD2 sets PX < 0 when it is executed. Note that Z is declared APPEND but it need not be declared SAVE since it is referenced outside the loop, whereas Y must be saved since it is an internal data block that is to be appended. X is an internal data block that is to be saved since it will only be generated the first time through the loop but is needed as input each time the loop is repeated. W is an internal data block that is generated each time through the loop; therefore it is not saved.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table. Data blocks A and B are assumed to be generated by the input file processor, and hence are considered referenced outside of all DMAP loops.

Module being executed	Input status and comments	Output status and comments
MØD1	B-assumed generated by the input file processor	W, Y - generated
CØND	PX is 0	No transfer occurs since PX ≥ 0
MØD2	A-assumed generated by the input file processor	X - generated PX is set < 0
SAVE	PX < 0	The value created above is saved for subsequent use.
MØD3	W, X, Y are all generated at this point	Z - generated
REPT	Loop count is initially set at 1	Transfer to L1 - set loop count to 1-1=0 Status of data blocks at top of loop will be: A, B, Z - generated (referenced outside loop) X, Y - generated (internal data blocks declared saved) W - not generated (internal data block)
MØD1	B - generated	W - generated Y - generated (appended)
CØND	PX is now < 0 due to SAVE	Transfer to L3 occurs
MØD3	W, X, Y - generated	Z - generated (appended)
REPT	Loop count is now 0	No transfer occurs.
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem.

5.2.3.2 The EQUIV Instruction (see Section 5.3.4)

There are no restrictions on the status of data blocks referenced in an EQUIV instruction. Consider the instruction EQUIV $A,B_1,\text{---},B_N/P$ \$ when $P < 0$. Data blocks $B_1,\text{---},B_N$ take on all the characteristics of data block A including the status of A. This means the status of some B_j can change from purged to generated or not generated.

The EQUIV instruction will unequivalence data blocks when $P \geq 0$. In an unequivalence operation, the status of all secondary data blocks reverts to not generated.

Suppose A, B, and C are all equivalenced and $P \geq 0$. EQUIV A,B/P \$ will break the equivalence between A and B but not between A and C.

Now consider the following situation. Data block B is to be generated by repeatedly executing functional module MØD2. The input to MØD2 is the previous output from MØD2. That is to say, each successive generation of B depends on the previous B generated. The following example shows how the EQUIV instruction is used to solve this problem. Assume parameter BREAK ≥ 0 and parameter LINK < 0.

<u>EXAMPLE</u> of EQUIV instruction.

```
                BEGIN    $
                MØD1     A/B  $
             (  LABEL    L1  $
DMAP         |  EQUIV    B,BB/BREAK  $
loop        <   MØD2     B/BB  $
             |  EQUIV    BB,B/LINK  $
             (  REPT     L1,1  $
                MØD3     BB//  $
                END      $
```

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	A-assumed generated by input processor	B - generated
EQUIV	B will not be equivalenced to BB since BREAK ≥ 0.	No action taken.
MØD2	B-generated	BB - generated
EQUIV	BB and B are not equivalenced. B - generated BB - generated LINK < 0.	B is equivalenced to BB. That is, B assumes all of the characteristics of BB. B and BB then both have the status of generated.
REPT	Loop count is initially 1	Transfer to L1; set loop count to 1-1=0.
EQUIV	B and BB are generated and equivalenced. BREAK ≥ 0.	The equivalence is broken; B - generated, BB - not generated
MØD2	B-generated	BB - generated
EQUIV	BB and B are generated and not equivalenced. LINK < 0.	B equivalenced to BB; B,BB - generated
REPT	Loop count is 0	No transfer occurs.
MØD3	BB - generated	Output to printer (assumed)
END		Normal termination of problem.

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Since equivalences are automatically broken between internal files (not declared saved) and files referenced outside the loop, the above DMAP program could be written as follows and the same results achieved.

```
              BEGIN    $
              MØD1     A/B  $
            ( LABEL    L1  $
DMAP        ) MØD2     B/BB  $
loop        ) EQUIV    BB,B/LINK  $
            ( REPT     L1,1  $
              MØD3     B//  $
              END      $
```

Data block BB is now internal; therefore, the instruction EQUIV B,BB/BREAK $ is not needed.

5.2.3.3 The PURGE Instruction (see Section 5.3.4)

The status of a data block is changed to purged by explicitly or implicitly purging it. A data block is explicitly purged through the PURGE instruction, whereas it is implicitly purged if it is not created by the functional module in which it appears as an output.

The primary purpose of the PURGE instruction is to prepurge data blocks. Prepurging is the explicit purging of a data block prior to its appearance as output from a functional module. Prepurging data blocks allows the NASTRAN executive system to allocate available files more efficiently which decreases problem execution time. The DMAP programmer should look for data blocks that can be prepurged and purge them as soon as it is recognized that they will not be generated.

Sometimes during the execution of a problem it is necessary to generate a data block whose status is purged. This situation can occur both in DMAP looping and in a modified restart situation. In order to generate a data block that is purged it is first necessary to unpurge it (i.e., change its status from purged to not generated). Unpurging is achieved by executing a PURGE instruction which references the purged data block and whose purge parameter is positive.

The PURGE instruction thus has two functions, to unpurge as well as purge data blocks depending on the value of the purge parameter and the status of the referenced data block. The following table shows what action is taken by the PURGE instruction for all combinations of input.

PURGE A/P $		
Status of data block A prior to PURGE	Value of P	Status of Data block A after PURGE
Not generated Not generated	$P \geq 0$ $P < 0$	Not generated (i.e., no action taken) Purged
Generated Generated	$P \geq 0$ $P < 0$	Generated (i.e., no action taken) Purged
Purged Purged	$P \geq 0$ $P < 0$	Not generated (i.e., unpurged) Purged (i.e., no action taken)

The user may wonder why he should not prepurge all data blocks and then unpurge them when necessary in order to really assist the file allocator. One should not do this, since there is a limited amount of space in the table where the status of data blocks is kept. One may overflow this table if too many data blocks are purged at one time. Therefore, only prepurge those data blocks that can truly be prepurged.

EXAMPLE of explicit and implicit purging and prepurging.

```
BEGIN    $
MØD1     IP/A/V,Y,PX/V,Y,PY/V,Y,PB  $
SAVE     PX,PY,PB  $
PURGE    X/PX / Y/PY  $
MØD2     A/B,C,D/V,Y,PB/V,Y,PC  $
SAVE     PC  $
PURGE    C/PC  $
MØD3     B,C,D/E  $
MØD4     E/X,Y,Z  $
MØD5     X,Y,Z//  $
END      $
```

Assume that module MØD1 sets PX < 0, PY ≥ 0 and PB = 0. Assume that B is not generated by MØD2 if PB = 0. Assume that MØD2 sets PC < 0, but does not change PB.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by the input file processor	A - generated PX < 0, PY ≥ 0, PB = 0
SAVE	PX < 0, PY ≥ 0, PB = 0	Parameter values are saved for use in subsequent modules.
PURGE	X,Y-not generated PX < 0, PY ≥ 0	X - purged (i.e., prepurged) Y - not generated
MØD2	A - generated; PB = 0	B - purged (i.e., implicitly); C, D - generated; PC < 0.
SAVE	PC < 0	PB value not saved since MØD2 did not reset it.
PURGE	C - generated PC < 0	C - purged
MØD3	B, C - purged D - generated	E - generated
MØD4	E - generated	X - purged; Y - generated; Z - generated
MØD5	X - purged Y, Z - generated	Output to printer (assumed)
END		Normal termination of problem.

EXAMPLE of unpurging.

```
             BEGIN    $
             FILE     X=SAVE/Y=SAVE  $
             FILE     Z=APPEND $
             MØD1     IP/A  $
            ⎧LABEL    L1  $
            ⎪CØND     L2,NPX  $
            ⎪PURGE    X/NPX  $
            ⎪MØD2     A/X,Y/V,Y,PX=0/V,N,NPX=0 $
   DMAP     ⎨SAVE     PX,NPX $
   loop     ⎪PURGE    X/PX  $
            ⎪LABEL    L2  $
            ⎪MØD3     X,Y/Z  $
            ⎩REPT     L1,2  $
             MØD4     Z// $
             END      $
```

Assume that MØD2 sets PX<0 and NPX≥0 the first time it is executed. Assume that MØD2 sets PX ≥ 0 and NPX < 0 the second time it is executed.

The following table shows what happened when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by input file processor.	A - generated
CØND	NPX = 0	Jump not executed
PURGE	X - not generated	X - not generated (i.e., no action taken)
MØD2	A - generated	X, Y - generated; PX < 0, NPX ≥ 0
SAVE	PX < 0, NPX ≥ 0	
PURGE	X - generated; PX < 0	X - purged
MØD3	X - purged; Y - generated	Z - generated
REPT	Loop count = 2	Transfer to location L1; Loop count = 1
CØND	NPX ≥ 0	Jump not executed
PURGE	X - purged; NPX ≥ 0	X - not generated (i.e., unpurged)
MØD2	A - generated	X - generated; Y - generated (note old data for Y is lost because Y not Appended); PX ≥ 0, NPX < 0
SAVE	PX ≥ 0, NPX < 0	
PURGE	X - generated; PX ≥ 0	X - generated (i.e., no action taken)
MØD3	X,Y - generated	Z - generated (note new data appended to old because Z declared appended)
REPT	Loop count = 1	Transfer to location L1; Loop count = 0
CØND	NPX < 0	Transfer to location L2
MØD3	X, Y - generated	Z - generated (i.e., appended)
REPT	Loop count = 0	Fall through to next instruction
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem

5.2.3.4 The CHKPNT Instruction (see Section 5.3.4)

The CHKPNT instruction provides the user with a means for saving data blocks for subsequent restart of his problem with a minimum amount of redundant processing. The following rules will assure the DMAP programmer of the most efficient restart.

1. Checkpoint all output data blocks from every functional module.

2. Checkpoint all data blocks mentioned in a PURGE instruction.

3. Checkpoint all secondary data blocks in an EQUIV instruction. Never checkpoint primary data blocks in an EQUIV instruction.

EXAMPLE of checkpointing.

```
BEGIN  $
MØD1   A/B,C/V,Y,P1/V,Y,P2  $
SAVE   P1,P2  $
CHKPNT B,C  $
PURGE  X,Y/P1 / Z/P2  $
CHKPNT X,Y,Z  $
EQUIV  B,BB/P1 / C,CC,D/P2  $
CHKPNT BB,CC,D  $
  .
  .
  .

END    $
```

The same results are achieved if the above program is written as:

```
BEGIN  $
MØD1   A/B,C/V,YP1/V,Y,P2  $
SAVE   P1,P2  $
PURGE  X,Y/P1 / Z/P2  $
EQUIV  B,BB/P1 / C,CC,D/P2  $
CHKPNT B,C,X,Y,Z,BB,CC,D  $
  .
  .
  .

END    $
```

In the first example the data blocks were checkpointed as soon as possible, which is the most straightforward way, but it required three calls to the checkpoint module, which increases problem execution time. The second way is therefore more efficient but not quite so straightforward. Since checkpointing usually requires a small fraction of the total execution time, it is recommended that the user use the most straightforward method to avoid trouble. The rigid format DMAP sequences have been designed for efficiency and, consequently, they appear more complex than they really are.

5.3 DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

<u>Matrix Operation Modules</u> (12)

(See page 5.3-3)

ADD	PARTN
ADD5	SMPYAD
DECØMP	SØLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN

<u>Utility Modules</u> (20)

(See page 5.3-16)

INPUT	PARAML
INPUTT1	PARAMR
INPUTT2	PRTPARM
MATGPR	SEEMAT
MATPRN	SETVAL
MATPRT	TABPCH
ØUTPUT1	TABPRT
ØUTPUT2	TABPT
ØUTPUT3	TIMETEST
PARAM	VEC

<u>User Modules</u> (14)

(See page 5.3-28)

DDR	MØDA
DUMMØD1	MØDB
DUMMØD2	MØDC
DUMMØD3	ØUTPUT
DUMMØD4	ØUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

<u>Executive Operation Modules</u> (12)

(See page 5.3-48)

BEGIN	FILE
CHKPNT	JUMP
CØND	LABEL
END	PURGE
EQUIV	REPT
EXIT	SAVE

<u>Structurally Oriented Modules</u> (53)

(See Section 4 of the Programmer's Manual)

BMG	GP4	PRTMSG	SMA3
CASE	GPSP	RANDØM	SMP1
CEAD	GPWG	RBMG1	SMP2
DDR1	MCE1	RBMG2	SSG1
DDR2	MCE2	RBMG3	SSG2
DPD	MTRXIN	RBMG4	SSG3
DSMG1	ØFP	READ	SSG4
DSMG2	PLA1	SCE1	TA1
FRRD	PLA2	SDR1	TRD
GKAD	PLA3	SDR2	VDR
GKAM	PLA4	SDR3	XYPLØT
GP1	PLØT	SMA1	XYTRAN
GP2	PLTSET	SMA2	
GP3	PLTTRAN		

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.

2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

Form	Meaning
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

Type	Meaning
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

Precision Indicator	Meaning
1	Single precision numbers
2	Double precision numbers

5.3.1 Matrix Operations Modules

Module	Basic Operation	Page
ADD	$[X] = a[A] + b[B]$	5.3-4
ADD5	$[X] = a[A] + b[B] + c[C] + d[D] + e[E]$	5.3-4a
DECØMP	$[A] \Rightarrow [L][U]$	5.3-5
FBS	$[X] = ([L][U])^{-1} [B]$	5.3-6
MERGE	$[A] \Leftarrow \left[\begin{array}{c\|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$	5.3-7
MPYAD	$[X] = [A][B] + [C]$	5.3-8
PARTN	$[A] \Rightarrow \left[\begin{array}{c\|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$	5.3-9
SMPYAD	$[X] = [A][B][C][D][E] + [F]$	5.3-12
SØLVE	$[X] = [A]^{-1} [B]$	5.3-14
TRNSP	$[X] = [A]^T$	5.3-15
UMERGE	$\left\{PHIF\right\} \Leftarrow \left\{\frac{PHIA}{PHIØ}\right\}$	5.3-15a
UPARTN	$[K_{ii}] = \left[\begin{array}{c\|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$	5.3-15b

I. NAME: ADD (Matrix Add)

II. PURPØSE: To compute [X] = a[A] + b[B] where a and b are scale factors.

III. DMAP CALLING SEQUENCE:

ADD A,B / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) $

IV. INPUT DATA BLØCKS:

A - Any matrix

B - Any matrix

Note: [A] and/or [B] may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. ØUTPUT DATA BLØCKS:

X - matrix.

The type of [X] is maximum of the types of [A], [B], a, b. The size of [X] is the size of [A] if [A] is present. Otherwise it is that of [B].

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

Note: If Im(ALPHA) or Im(BETA) = 0.0 the corresponding parameter will be considered real.

I. NAME: ADD5 (Matrix Add)

II. PURPØSE: To compute [X] = a[A] + b[B] + c[C] + d[D] + e[E] where a, b, c, d and e are scale factors.

III. DMAP CALLING SEQUENCE:

```
ADD5  A,B,C,D,E / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) / C,Y,GAMMA=(5.0,6.0) /
                       C,Y,DELTA=(7.0,8.0) / C,Y,EPSLN=(9.0,1.0) $
```

IV. INPUT DATA BLØCKS:

A, B, C, D, and E must be distinct matrices.

Note: Any of the matrices may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. ØUTPUT DATA BLØCKS:

X - matrix.

The type of [X] is maximum of the types of A, B, C, D, E, a, b, c, d, e. The size of [X] is the size of the first nonpurged input.

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

GAMMA - Input-complex-single precision, default = (1.0, 0.0). This is c, the scalar multiplier for [C].

DELTA - Input-complex-single precision, default = (1.0, 0.0). This is d, the scalar multiplier for [D].

EPSLN - Input-complex-single precision, default = (1.0, 0.0). This is e, the scalar multiplier for [E].

Note: If Im(ALPHA), Im(BETA), Im(GAMMA), Im(DELTA), or Im(EPSLN) = 0.0, the corresponding parameter will be considered real.

I. DECØMP (Matrix Decomposition)

II. PURPØSE: To decompose a square matrix [A] into upper and lower triangular factors [U] and [L] .

$$[A] \Rightarrow [L][U]$$

III. DMAP CALLING SEQUENCE:

DECØMP A / L,U / V,Y,KSYM / V,Y,CHØLSKY / V,N,MINDIAG / V,N,DET / V,N,PØWER / V,N,SING $

IV. INPUT DATA BLØCKS:

A - A square matrix

V. ØUTPUT DATA BLØCKS:

L - Nonstandard lower triangular factor of [A].

U - Nonstandard upper triangular factor of [A].

VI. PARAMETERS:

KSYM - Input-integer, default = 1. 1, use symmetric decomposition. 0, use unsymmetric decomposition.

CHØLSKY - Input-integer, default = 0. 1, use Cholesky decomposition - matrix must be positive definite. 0, do not use Cholesky decomposition.

MINDIAG - Output-real double precision, default = 0.0D0. The minimum diagonal term of [U].

DET - Output-complex single precision, default = 0.0D0. The scaled value of the determinant of [A].

PØWER - Output-integer, default = 0. Integer PØWER of 10 by which DET should be multiplied to obtain the determinant of [A].

SING - Output-integer, default = 0. SING is set to -1 if [A] is singular.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process in module FBS. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

3. If the CHØLSKY option is selected, the resulting factor (which will be written as [U]) cannot be input to FBS.

4. Variable parameters output from functional modules must be SAVEd if they are to be subsequently used. See the Executive Module SAVE description.

I. NAME: FBS (Matrix Forward-Backward Substitution)

II. PURPØSE: To solve the matrix equation [L][U][X] = ±[B] where [L] and [U] are the lower and upper triangular factors of a matrix previously obtained via Functional Module DECØMP.

III. DMAP CALLING SEQUENCE:

```
FBS  L,U,B / X / C,N,a / C,N,b / C,N,c / C,N,d $
```

IV. INPUT DATA BLØCKS:

L - Nonstandard lower triangular factor

U - Nonstandard upper triangular factor

B - Rectangular matrix

V. ØUTPUT DATA BLØCKS:

X - Rectangular matrix having the same dimensions as [B].

VI. PARAMETERS:

a - Input-integer, default = 1. $\begin{cases} 1 & \text{matrix [L][U] is symmetric} \\ 0 & \text{matrix [L][U] is unsymmetric} \end{cases}$

b - Input-integer, default = 1. $\begin{cases} 1 & \text{solve [L][U][X] = [B]} \\ -1 & \text{solve [L][U][X] = -[B]} \end{cases}$

c - Input-integer, default = 2. $\begin{cases} 1 & \text{- use single precision arithmetic} \\ 2 & \text{- use double precision arithmetic} \end{cases}$

d - Input-integer, default = 2. $\begin{cases} 1 & \text{- output [X] in single precision} \\ 2 & \text{- output [X] in double precision} \end{cases}$

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

I. NAME: MERGE (Matrix Merge)

II. PURPØSE: To form the matrix [A] from its partitions:

$$
\begin{array}{ccc}
 & & \xleftrightarrow{\quad CP \quad} \\
[A] <= & RP \updownarrow & \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right] \begin{array}{l} = 0 \\ \neq 0 \end{array} \\
 & & \begin{array}{cc} = 0 & \neq 0 \end{array}
\end{array}
$$

III. DMAP CALLING SEQUENCE:

MERGE A11,A21,A12,A22,CP,RP / A / V,Y,SYM / V,Y,TYPE / V,Y,FØRM $

IV. INPUT DATA BLØCKS:

A11 - Matrix

A21 - Matrix

A12 - Matrix

A22 - Matrix

RP - Row partitioning vector (see below) - Single precision column vector.

CP - Column partitioning vector (see below) - Single precision column vector.

Notes:

1. Any or all of [A11], [A12], [A21], [A22] can be purged. When all are purged this implied [A] = [0].
2. {RP} and {CP} may not both be purged.
3. See Remarks for meaning when either of {RP} or {CP} is purged.
4. [A11], [A12], [A21], [A22] must be unique matrices.

V. ØUTPUT DATA BLØCKS:

A - merged matrix from [A11], [A12], [A21], [A22]

Notes: [A] cannot be purged.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM < 0, {CP} is used for {RP}. SYM $\geq$ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 2. Type of [A]

FØRM - Input-integer, default = 0. Form of [A] (see Remarks)

VII. REMARKS:

1. MERGE is the inverse of PARTN in the sense that if [A11], [A12], [A21], [A22] were produced by PARTN using {RP}, {CP}, FØRM, SYM, and TYPE from [A], MERGE will produce [A]. See PARTN for options on {RP}, {CP} and SYM.
2. All input data blocks must be distinct.
3. When FORM = 0, a compatible matrix [A] results as shown in the following table:

DIRECT MATRIX ABSTRACTION

		Form of A22		
		Square	Rectangular	Symmetric
Form of A11	Square	Square	Rectangular	Rectangular
	Rectangular	Rectangular	Rectangular	Rectangular
	Symmetric	Rectangular	Rectangular	Symmetric

I. NAME: MPYAD (Matrix Multiply and Add)

II. PURPØSE: MPYAD performs the multiplication of two matrices and, optionally, addition of a third matrix to the product. By means of parameters, the user may compute $\pm[A][B] \pm [C]$, or $\pm[A]^T[B] \pm [C]$.

III. DMAP CALLING SEQUENCE:

MPYAD A,B,C / X / V,N,T / V,N,SIGNAB / V,N,SIGNC / V,N,PREC $

IV. INPUT DATA BLØCKS:

A - Left hand matrix in the matrix product [A][B]

B - Right hand matrix in the matrix product [A][B]

C - Matrix to be added to [A][B]

Notes:

1. If no matrix is to be added, [C] must be purged.
2. [A], [B], [C] must be physically different data blocks.
3. [A] and [B] must not be purged.

V. ØUTPUT DATA BLØCK:

X - Matrix resulting from the MPYAD operation.

Note: [X] may not be purged.

VI. PARAMETERS:

T - Integer-input, no default. $T = \begin{cases} 1, \text{ perform } [A]^T[B] \\ 0, \text{ perform } [A][B] \end{cases}$

SIGNAB - Integer-input,default = 1. $SIGNAB = \begin{cases} +1, \text{ perform } [A][B] \\ 0, \text{ omit } [A][B] \\ -1, \text{ perform } -[A][B] \end{cases}$

SIGNC - Integer-input, default = 1. $SIGNC = \begin{cases} +1, \text{ add } [C] \\ 0, \text{ omit } [C] \\ -1, \text{ subtract } [C] \end{cases}$

PREC - Integer-input, default = 2. $PREC = \begin{cases} 1, \text{ elements of } [X] \text{ will be output in single-precision} \\ 2, \text{ elements of } [X] \text{ will be output in double-precision} \end{cases}$

VII. EXAMPLES:

1. $[X] = [A][B]+[C]$ ([X] double-precision)
   MPYAD A,B,C / X / C,N,0 $

2. $[X] = [A]^T[B]-[C]$ ([X] single-precision)
   MPYAD A,B,C / X / C,N,1 / C,N,1 / C,N,-1 / C,N,1 $

3. $[X] = -[A][B]$ ([X] double-precision)
   MPYAD A,B, / X / C,N,0 / C,N,-1 $

I. NAME: PARTN (Matrix Partition)

II. PURPØSE: To partition [A] into [A11], [A12], [A21] and [A22]:

$$[A] \Longrightarrow \begin{array}{cc} & \xleftarrow{\quad CP \quad}\!\!\xrightarrow{} \\ RP\updownarrow & \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right] \begin{array}{l} = 0 \\ \neq 0 \end{array} \\ & \begin{array}{cc} = 0 & \neq 0 \end{array} \end{array}$$

III. DMAP CALLING SEQUENCE:

```
PARTN A,CP,RP / A11,A21,A12,A22 / V,Y,SYM / V,Y,TYPE / V,Y,F11 / V,Y,F21 / V,Y,F12 / V,Y,F22 $
```

IV. INPUT DATA BLØCKS:

A - Matrix to be partitioned.

RP - Row partitioning vector - single precision column vector.

CP - Column partitioning vector - single precision column vector.

V. ØUTPUT DATA BLØCKS:

A11 - Upper left partition of [A]

A21 - Lower left partition of [A]

A12 - Upper right partition of [A]

A22 - Lower right partition of [A]

Notes: 1. Any or all output data blocks may be purged.
2. For size of outputs see METHØD section below.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM chooses between a symmetric partition and one unsymmetric partition. If SYM < 0, {CP} is used as {RP}. If SYM $\geq$ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 2. Type of output matrices.

F11 - Input-integer, default = 0. Form of [A11].
F21 - Input-integer, default = 0. Form of [A21].
F12 - Input-integer, default = 0. Form of [A12].
F22 - Input-integer, default = 0. Form of [A22].

} See Remarks

VII. METHØD:

Let NC = number of nonzero terms in {CP}.

Let NR = number of nonzero terms in {RP}.

Let NRØWA = number of rows in [A].

Let NCØLA = number of columns in [A].

Case 1 {CP} purged and SYM $\geq$ 0.

[A11] is a (NRØWA-NR) by NCØLA matrix.

[A21] is a NR by NCØLA matrix.

[A12] is not written.

[A22] is not written.

$$[A] \rightarrow \left[\begin{array}{c} A11 \\ \hdashline A21 \end{array}\right]$$

CASE 2 {RP} purged and SYM $\geq$ 0

[A11] is a NRØWA by (NCØLA - NC) matrix.

[A21] is not written.

[A12] is a NRØWA by NC matrix.

[A22] is not written.

$$[A] \rightarrow [A11 \mid A12]$$

CASE 3 SYM < 0 ({RP} must be purged)

[A11] is a (NRØWA - NC) by (NCØLA - NC) matrix.

[A21] is a NC by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NC) by NC matrix.

[A22] is a NC by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

CASE 4 neither {CP} nor {RP} purged and SYM $\geq$ 0

[A11] is a (NRØWA - NR) by (NCØLA - NC) matrix.

[A21] is a NR by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NR) by NC matrix.

[A22] is a NR by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

VIII. REMARKS:

1. If [A] is purged, PARTN will cause all output data blocks to be purged.
2. If {CP} is purged, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c} A11 \\ \hline A21 \end{array}\right].$$

3. If {RP} is purged and SYM $\geq$ 0, [A] is partitioned as follows:

$$[A] \Rightarrow [A11 \mid A12]$$

4. If {RP} is purged and SYM < 0, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right].$$

where {CP} is used as both the row and column partitioner.

5. {RP} and {CP} cannot both be purged.
6.

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

Let [A] be a m by n order matrix.

Let {CP} be a n order row matrix containing q zero elements.

Let {RP} be a m order column vector containing p zero element.

Partition [A11] will consist of all elements A_{ij} of [A] for which $CP_j = RP_i = 0$ in the same order as they appear in [A].

Partition [A12] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i = 0$ in the same order as they appear in [A].

Partition [A21] will consist of all elements A_{ij} of [A] for which $CP_j = 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

Partition [A22] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

7. If the defaults for F11, F21, F12, or F22 are used, the corresponding matrix will be output with a compatible form entered in the trailer.

IX. EXAMPLES:

1. Let [A], {CP} and {RP} be defined as follows:

$$[A] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \\ 9.0 & 10.0 & 11.0 & 12.0 \end{bmatrix}, \quad \{CP\} = \begin{Bmatrix} 1.0 \\ 0.0 \\ 1.0 \\ 1.0 \end{Bmatrix}, \quad \{RP\} = \begin{Bmatrix} 0.0 \\ 0.0 \\ 1.0 \end{Bmatrix}$$

Then, the DMAP instruction

```
PARTN  A,CP,RP / A11,A21,A12,A22 / C,N,1 $
```

will create the real double precision matrices

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \end{bmatrix}, \ F11 = 2 \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \end{bmatrix}, \ F12 = 2$$

$$[A21] = [10.0], \ F21 = 1 \qquad [A22] = [9.0 \quad 11.0 \quad 12.0], \ F22 = 2$$

2. If, in Example 1, the DMAP instruction were written as

```
PARTN  A,CP, / A11,A21,A12,A22 / C,N,1 $
```

the resulting matrices would be

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \\ 10.0 \end{bmatrix} \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \\ 9.0 & 11.0 & 12.0 \end{bmatrix}$$

[A21] = purged   [A22] = purged

3. If, in Example 1, the DMAP instruction were written as

```
PARTN  A,,RP / A11,A21,A12,A22 / C,N,1 $
```

the resulting matrices would be

$$[A11] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \end{bmatrix} \qquad [A12] = \text{purged}$$

$$[A21] = [9.0 \quad 10.0 \quad 11.0 \quad 12.0] \qquad [A22] = \text{purged}$$

I. NAME. SMPYAD (Matrix Series Multiply and Add)

II. PURPØSE: To multiply a series of matrices together:

$$[X] = [A][B][C][D][E] \pm [F].$$

III. DMAP CALLING SEQUENCE:

```
SMPYAD  A,B,C,D,E,F / X / C,N,n / V,N,SIGNX / V,N,SIGNF / V,N,PX / V,N,TA /
                        V,N,TB / V,N,TC / V,N,TD $
```

IV. INPUT DATA BLØCKS:

A, B, C, D, E - Up to 5 matrices to be multiplied together, from left to right.

F - Matrix to be added to the above product.

Notes:

1. If one of the five multiplication matrices is required in the product (see Parameter n below) and is purged, the multiplication will not be done.
2. If the [F] matrix is purged, no matrix will be added to the product.

V. ØUTPUT DATA BLØCKS:

X - Resultant matrix (may not be pre-purged)

VI. PARAMETERS:

1. n = number of matrices involved in the product, counting from the left (integer, input)
2. SIGNX = sign of the product matrix (e.g., [A][B][C][D][E])
   = 1 for plus, -1 for minus (integer, input)
3. SIGNF = sign of the matrix to be added to the product matrix (integer, input)
   = 1 for plus, -1 for minus
4. PX = output precision of the final result (integer, input)
   = 1 for single-precision, 2 for double-precision
5. TA, TB, TC, TD = transpose indicators for the [A],[B],[C], and [D] matrices (1 if transposed matrix to be used in the product; 0 if untransposed) - (integer, input)

Note:

All the parameters except n have default values as follows:

SIGNX = 1 (sign of product is plus)

SIGNF = 1 (sign of added matrix is plus)

PX = 2 (double-precision result)

TA, TB, TC, TD = 0 (use untransposed [A],[B],[C], and [D] matrices in the product)

VII. METHØD:

The method is the same as for the MPYAD module with the following additional remarks -

1. None of the matrices may be diagonal.
2. Except for the final product, all intermediate matrix products are generated in double-precision.
3. The matrices are post-multiplied together from right-to-left, i.e., the first product calculated is the product of matrix n-1 and matrix n.

VIII. EXAMPLES:

1. To compute $[X] = [A][B]^T[C]-[F]$, use

   ```
   SMPYAD  A,B,C,,,F / X / C,N,3 / C,N,1 / C,N,-1 / C,N,2 / C,N,0 / C,N,1 $
   ```

2. To compute $[Z] = -[U]^T[V]^T[W]^T[X]^T[Y]$, use

   ```
   SMPYAD  U,V,W,X,Y, / Z / C,N,5 / C,N,-1 / C,N,0 / C,N,2 / C,N,1 / C,N,1 /
                      C,N,1 / C,N,1 $
   ```

I. NAME: SØLVE (Linear System Solver)

II. PURPØSE: To solve the Matrix Equation

$$[A][X] = \pm[B]$$

III. DMAP CALLING SEQUENCE:

SØLVE A,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE $

IV. INPUT DATA BLØCKS:

A - square real or complex matrix

B - rectangular real or complex matrix (if purged, the identity matrix is assumed.)

V. ØUTPUT DATA BLØCKS:

X - A rectangular matrix

Note: A standard matrix trailer will be written, identifying [X] as a rectangular matrix with the same dimensions as [B] and the type specified.

VI. PARAMETERS:

SYM - Input-integer, default = 0
- 0 - use unsymmetric decomposition
- 1 - use symmetric decomposition
- -1 - try symmetric decomposition, use unsymmetric if any leading minor of [A] is singular

SIGN - Input-integer,default = 1
- 1 - solve [A][X] = [B]
- -1 - solve [A][X] = -[B]

PREC - Input-integer,default = 2
- 1 - use single precision arithmetic
- 2 - use double precision arithmetic

TYPE - Input-integer,default = 2
- 1 - output type of matrix [X] is real single precision
- 2 - output type of matrix [X] is real double precision
- 3 - output type of matrix [X] is complex single precision
- 4 - output type of matrix [X] is complex double precision

VII. METHØD: Depending on the SYM flag and the type of [A], one of subroutines SDCØMP, DECØMP, or CDCØMP is called to form [A] = [L][U].

One of FBS or GFBS is then called to solve [L][Y] = ±[B] and [L][X] = [Y], as appropriate.

I. NAME: TRNSP (Matrix Transpose)

II. PURPØSE: To form $[A]^T$ given [A].

III. DMAP CALLING SEQUENCE:

TRNSP A/X $

IV. INPUT DATA BLØCKS:

A - Any matrix data block.

Note: If [A] is purged, TRNSP will cause [X] to be purged.

V. ØUTPUT DATA BLØCKS:

X - The matrix transpose of [A]

Note: [X] cannot be purged.

VI. PARAMETERS: None.

VII. REMARKS:

1. Transposition of large full matrices is very expensive and should be avoided if possible (see Section 2.1.4 of the Theoretical Manual).

2. TRNSP currently uses algorithms which assumes that the matrix is dense. This algorithm is extremely inefficient for sparce matrices. Sparce matrices should be transposed by using MPYAD.

I. NAME: UMERGE (Merges two matrices based on USET)

II. PURPØSE: To merge two column matrices (such as load vectors or displacement vectors) into a single matrix.

III. DMAP CALLING SEQUENCE:

```
UMERGE  USET,PHIA,PHIØ / PHIF / V,N,MAJØR=F / V,N,SUBO=A / V,N,SUB1=L $
```

IV. INPUT DATA BLØCKS:

USET - Uset [or U-set (Dynamics)]

PHIA
PHIØ
Any matrices

Note: 1. USET may not be purged.

2. PHIA or PHIØ may be purged in which case their respective elements will be zero.

3. PHIA, PHIØ and PHIF must be related by the following matrix equation

$$\left\{\frac{PHIA}{PHI\emptyset}\right\} \Longrightarrow \left\{PHIF\right\}$$

V. ØUTPUT DATA BLØCKS:

PHIF - matrix

Note: PHIF must not be purged.

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.3-17 (Input, no default)

SUBO - BCD value from table on page 5.3-17 (Input, no default)

SUB1 - BCD value from table on page 5.3-17 (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

I. NAME: UPARTN (Partitions a matrix based on USET)

II. PURPØSE: To perform symmetric partitioning of displacement method matrices (particularly to allow user splitting of long running modules such as SMP1).

III. DMAP CALLING SEQUENCE:

```
UPARTN  USET,KII / KJJ,KLJ,KJL,KLL / V,N,MAJØR=I / V,N,SUBO=J / V,N,SUB1=L $
```

IV. INPUT DATA BLØCKS:

USET - U-set [or U-set (Dynamics)]

KII - Any displacement matrix

Note: 1. USET may not be purged

2. KII may be purged in which case UPARTN will simply return, causing the output matrices to be purged.

V. ØUTPUT DATA BLØCKS:

$$\left.\begin{array}{l} \text{KJJ} \\ \text{KLJ} \\ \text{KJL} \\ \text{KLL} \end{array}\right\} \text{matrix partitions}$$

Note: 1. Any or all output data block(s) may be purged.

2. UPARTN forms:

$$\left[K_{ii}\right] \Longrightarrow \left[\begin{array}{c|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$$

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.3-17 (Input, no default)

SUBO - BCD value from table on page 5.3-17 (Input, no default)

SUB1 - BCD value from table on page 5.3-17 (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

VII. EXAMPLE:

In Rigid Format 3 module SMP1 performs the following calculations:

SMP1 partitions the constrained stiffness and mass matrices

$$\left[K_{ff}\right] \Longrightarrow \left[\begin{array}{c|c} \overline{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

and

$$\left[M_{ff}\right] \Longrightarrow \left[\begin{array}{c|c} \overline{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

solves for transformation matrix

$$[G_o] = -[K_{oo}]^{-1} [K_{oa}]$$

and performs the matrix reductions

$$[K_{aa}] = [\overline{K}_{aa}] + [K_{oa}]^T [G_o]$$

and

$$[M_{aa}] = [\overline{M}_{aa}] + [M_{oa}]^T [G_o] + [G_o]^T [M_{oa}] + [G_o]^T [M_{oo}] [G_o]$$

Step 1 can be performed by two applications of UPARTN:

UPARTN USET,KFF / KAAB,KØA,,KØØ / C,N,F / C,N,A / C,N,Ø $

UPARTN USET,MFF / MAAB,MØA,,MØØ / C,N,F / C,N,A / C,N,Ø $

Step 2 can be performed by SØLVE

SØLVE KØØ,KØA / GØ / C,N,1 / C,N,-1 $

KAA and MAA can be computed by a sequence of applications of the MPYAD module.

Note that checkpoints can be inserted as desired to breakup a long running module into several smaller steps.

5.3.2 Utility Modules

Module	Basic Function	Page
INPUT	Generate most of bulk data for selected academic problems	5.3-16a
INPUTT1	Read data blocks from GINØ-written user tapes	5.3-16b
INPUTT2	Read data blocks from FØRTRAN-written user tapes	5.3-16h
MATGPR	Print Matrices with Grid Point Identification	5.3-17
MATPRN	Print Matrices	5.3-19
MATPRT	Print Matrices associated only with geometric grid points	5.3-20
ØUTPUT1	Write data blocks via GINØ onto user tapes	5.3-20a
ØUTPUT2	Write data blocks via FØRTRAN onto user tapes	5.3-20h
ØUTPUT3	Punch matrices onto DMI cards	5.3-20ℓ
PARAM	Manipulate Parameter values	5.3-21
PARAML	Selects parameters from a user input matrix or table	5.3-21b
PARAMR	Performs specified arithmetic, logical and conversion operations on real or complex parameters	5.3-21c
PRTPARM	Print parameter values and DMAP error messages	5.3-22
SEEMAT	Generate Matrix Topology Displays	5.3-24
SETVAL	Set parameter values	5.3-26
TABPCH	Punch NASTRAN tables on DTI cards	5.3-26a
TABPRT	Print selected table data blocks using readable format	5.3-26b
TABPT	Print table data blocks	5.3-27
TIMETEST	Provides NASTRAN system timing data	5.3-27a
VEC	Generate partitioning vector	5.3-27b

Utility modules are an arbitrary sub-division of the Functional Modules.

Utility modules are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

I. NAME: INPUT (Input Generator)

II. PURPØSE: Generates the majority of the bulk data cards for selected academic problems. Used in many of the official NASTRAN Demonstration Problems.

III. DMAP CALLING SEQUENCE:

INPUT I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS:

Appropriate preface outputs.

V. ØUTPUT DATA BLØCKS:

Appropriate for the problem being generated.

VI. PARAMETERS:

The three parameters are used in conjunction with data read by INPUT from the input stream to define the problem being generated.

VII. METHØD:

Since INPUT is intimately related to bulk data card input, a detailed description of this module has been placed in Section 2.6.

I. NAME: INPUTT1 (Reads User Tapes)
(The companion module is ØUTPUT1)

II. PURPØSE: Recovers up to five data blocks from a user tape and checks the user tape label where the expected format is that created by Utility Module ØUTPUT1. Also used to position the user tape (including handling or multiple reel tapes) prior to reading the data blocks. Multiple calls are allowed. A message is written for each data block successfully recovered and after each tape reel switch.*

III. DMAP CALLING SEQUENCE:
INPUTT1 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
Input data blocks are not used in this module call statement.

V. ØUTPUT DATA BLØCKS:
DBi - Data blocks which will be recovered from one of the NASTRAN permanent tape files INPT, INP1, INP2, through INP9. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B.

*Currently user tape reel switching is available on IBM 360/370 and Univac 1108 only.

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-2	Mount new reel and position new reel past label (P3) before reading.
-3	Print data block names and then rewind before reading.
-4	Current tape reel will have an end-of-file mark written on it, will be rewound and dismounted and then a new tape reel will be mounted with ring out and rewound before reading the data blocks. This option should be used when a call to INPUTT1 is preceded by a call to ØUTPUT1 using the same User Tape.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

The third parameter (P3) for this module is used as the User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the user tape. The comparison of P3 and the value on the user tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-2	Yes (On new reel)
-3	Yes (Warning Check)
-4	Yes (On new reel)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES: (Most examples use the default value for P2 and P3 which means the use of permanent NASTRAN tape file INPT and NASTRAN user tape label of XXXXXXXX)

1. INPUTT1 / A,B,,, / $

   Read data blocks A and then B from user tape INPT starting from wherever INPT is currently positioned. If this is the first module to manipulate INPT, the tape will automatically be initially positioned at the beginning of the user tape label. In this case the first parameter of INPUTT1 must be set to either one (1) to skip past the label or minus one (-1) to rewind the tape and position it at the beginning of the first data block (A).

2. INPUTT1 / ,,,, / C,N,-1 / C,N,3 $

   Rewind INP3 and check user tape label.

3. INPUTT1 / A,,,, / C,N,-2 $

   Mount a new reel of tape (without write ring) for INPT and read data block A from the first file position. The label of the new reel of tape will be checked.

4. INPUTT1 / ,,,, / C,N,-2 $
   INPUTT1 / A,,,, / C,N,0 $

   This is equivalent to example 3.

5. INPUTT1 / A,B,C,D,E / C,N,14 $

   Starting from the current position, skip forward 14 data blocks on INPT and read the next five data blocks into A,B,C,D, and E. Do not check the user tape label.

6. INPUTT1 / ,,,, / C,N,-3 $
   INPUTT1 / A,B,C,D,E / C,N,14 $

   A complete list of data block names will be provided including a warning check of the user tape label. Then, it will be the same as example 5 only if the current position in that example were at the beginning of the first data block.

7. INPUTT1 / ,,,, / C,N,-2 $
   INPUTT1 / ,,,, / C,N,-3 $
   INPUTT1 / A,B,,, / C,N,14 $

   Mount a new reel of tape for INPT and check the new reel's label. Print the names of all data blocks on the new tape and give a warning check for tape label. Read the 15th and 16th data blocks into A and B. INPT will end up positioned at the beginning of the 17th data block if present.

VIII. MØRE DIFFICULT EXAMPLES USING BØTH INPUTT1 AND ØUTPUT1:

Example 1:

(a) Objectives:

(1) Obtain printout of the names of all data blocks on INPT.

(2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.

(3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

```
BEGIN $                                   (1)
INPUTT1  / ,,,, / C,N,-3 $                (2)
INPUTT1  / ,,T1,T2,T3 / C,N,6 $           (3)
INPUTT1  / ,,,, / C,N,-1 $                (4)
ØUTPUT1  A,B,T1,T2,T3 // C,N,4 $          (5)
ØUTPUT1, ,,,, // C,N,-3 $                 (6)
END $                                     (7)
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.

(2) DMAP sequence (3) recovers data blocks 7, 8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.

(3) DMAP sequence (4) rewinds INPT.

(4) DMAP sequence (5) accomplishes objective (2).

(5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.

(6) Note that INPUTT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

Example 2:

(a) Objectives:

(1) Write data blocks A, B, and C on INPT.

(2) Obtain printout of the names of all data blocks on INPT after step (1).

(3) Make two copies of the tape created in (1).

(4) Add data blocks D and E to one of the tapes.

(5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                              (1)
ØUTPUT1 A,B,C,, // C,N,-1 $          (2)
ØUTPUT1, ,,,, // C,N,-3 $            (3)
ØUTPUT1 A,B,C,, // C,N,-2 $          (4)
ØUTPUT1 A,B,C,, // C,N,-2 $          (5)
ØUTPUT1 D,E,,, // C,N,0 $            (6)
ØUTPUT1, ,,,, // C,N,-3 $            (7)
END $                                (8)
```

(c) Remarks:

(1) DMAP Sequence (2) accomplishes objective (1).

(2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(3) Statements (4) and (5) accomplish objective (3).

(4) Statement (6) accomplishes objective (4) where the third tape is used.

(5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1  A,B,C,, // C,N,-1 $
ØUTPUT1, ,,,, // C,N,-3 $
ØUTPUT1  A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1  A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1  D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1, ,,,, // C,N,-3 / C,N,2 $
END $
```

I. NAME: INPUTT2 (Reads User-Written FØRTRAN Tapes)
(The companion module is ØUTPUT2)

II. PURPØSE: Recovers up to five data blocks from a FØRTRAN-written user tape. This tape may be written either by a user-written FØRTRAN program or by the companion module ØUTPUT2. The Programmer's Manual describes the format of the tape which must be written in order to be readable by INPUTT2.

III. DMAP CALLING SEQUENCE:
INPUTT2 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
Input data blocks are not used in this module call statement.

V. ØUTPUT DATA BLØCKS:
DBi - Data blocks which will be recovered from one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B .

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-3	Print data block names and then rewind before reading.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

The second parameter (P2) for this module is the FØRTRAN unit number from which the data blocks will be read. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine and installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used as the FØRTRAN User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the FØRTRAN User Tape. The comparison of P3 and the value on the User Tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-3	Yes (Warning Check)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES:

INPUTT2 is intended to have the same logical action as the GINØ User Tape module INPUTT1 except for tape reel switching. It is therefore suggested that the examples shown under module INPUTT1 be used for INPUTT2 as well, excepting the ones involving tape reel switching.

DMAP MODULE DESCRIPTIONS

I. NAME: MATGPR (Displacement Approach Matrix Printer)

II. PURPØSE: Prints matrices generated by the Displacement Approach. External grid point identification of each nonzero element is also printed.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or matrices generated in Rigid Formats 7-12 prior to module GKAD (or GKAM):

```
MATGPR  GPL,USET,SIL,M // C,N,c / C,N,r $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

```
MATGPR  GPLD,USETD,SILD,M // C,N,c / C,N,r $
```

IV. INPUT DATA BLØCKS:

GPL - Grid Point List
GPLD - Grid Point List (Dynamics)
USET - U-set
USETD - U-set (Dynamics)
SIL - Scalar Index List
SILD - Scalar Index List (Dynamics)
M - Any displacement approach matrix

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. c-row size (number of columns) - must be the appropriate BCD value from the table below. (Input, no default)

2. r-column size (number of rows) - must be the appropriate BCD value from the table below. If not specified, it will be assumed that r=c. (Input, default = X which implies r=c)

MATGPR parameter value	Means matrix is same size as
M	U_m
Ø	U_o
R	U_r
SG	U_s (specified on GRID card)
SB	U_s (specified on SPC card)
L	U_ℓ
A	U_a
F	U_f
S	U_s (union of SG and SB)
N	U_n

G	U_g
E	U_e
P	U_p
NE	ξ_o
FE	ξ_i
D	U_d
H	U_h

Notes:

1. See Section 3.3 of the Theoretical Manual for a discussion of set notation.
2. If the value specified for c is not in the above table, the matrix will not be printed.
3. The user must know which sets correspond to the rows and columns of the matrix he wishes to print. This is usually apparent from the DMAP name of the matrix data block.

VII. REMARKS:

1. When using the form specified in IIIA, this module may not be scheduled until after GP4 since data blocks generated by GP4 are required inputs. When using the form specified in IIIB, this module may not be scheduled until after DPD since data blocks generated by DPD are required inputs.
2. If [M] is purged, no printing will be done.
3. The non-zero terms of the matrix will be printed along with the external grid point and component identification numbers corresponding to the row and column position of each term.

I. NAME: MATPRN (General Matrix Printer)

II. PURPØSE: To print general matrix data blocks.

III. DMAP CALLING SEQUENCE:

MATPRN M1,M2,M3,M4,M5 // $

IV. INPUT DATA BLØCKS:

Mi - Matrix data blocks, any of which may be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. ØUTPUT:

The nonzero band of each column of each input matrix data block is unpacked and printed in single precision.

VIII. NØTES:

1. Any or all input data blocks can be purged.
2. If any data block is not matrix type, the TABPT routine will be called.

IX. EXAMPLES:

1. MATPRN KGG,,,, // $
2. MATPRN KGG,PL,PG,BGG,UPV // $

I. NAME: MATPRT (Matrix Printer)

II. PURPOSE: To print matrix data blocks associated with grid points only.

III. DMAP CALLING SEQUENCE:

MATPRT X // C,N,rc / C,N,y $

IV. INPUT DATA BLOCK:

X - matrix data block to be printed. If [X] is purged, then nothing is done.

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. rc - indicates whether [X] is stored by rows (rc = 1) or by columns (rc = 0) (integer, input, default value = 0).

2. y - indicates whether [X] is to be printed even if not purged ($y < 0$, do not print [X]; $y \geq 0$, print [X]) (integer, input, default value = 0).

VII. METHOD:

Each column (or row) of the matrix is broken into groups of 6 terms (3 terms if complex) per printed line. If all the terms in a group = 0, the line is not printed. If the entire column (or row) = 0, it is not printed. If the entire matrix = 0, it is not printed.

VIII. REMARKS:

1. MATPRT should not be used if scalar or extra points are present. For this case, use MATPRN.

2. Only one matrix data block is printed by this instruction. The instruction may be repeated as many times as required, however.

I. NAME: ØUTPUT1 (Create User Tapes)
(The companion module is INPUTT1)

II. PURPØSE: Writes up to five data blocks and a user tape label onto a user tape for subsequent use at a later date. (See User Module INPUTT1 for recovery procedures.) ØUTPUT1 is also used to position the user tape (including handling of multiple reel tapes*) prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written and after each tape reel switch. The user is cautioned to be careful when positioning a user tape with ØUTPUT1 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.

III. DMAP CALLING SEQUENCE:
ØUTPUT1 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
DBi - Any data block which the user desires to be placed on one of the NASTRAN permanent tape files INPT, INP1, INP2 thru INP9. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.

V. ØUTPUT DATA BLØCKS: None.

*User tape reel switching is currently available only on the IBM 360/370 and Univac 1108 computers.

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing. (This is dangerous!)*
-2	Mount new reel before writing.**
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-4	Current tape reel will be rewound and dis-mounted and a new tape reel will be mounted with ring in and rewound before writing the data blocks. This option should be used when a call to ØUTPUT1 is preceded by a call to INPUTT1 using the same User Tape.

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

*An EØF is written at the end of each call to ØUTPUT1.

**An end-of-file mark is written on the tape to be switched. Caution should be used when switching from a user tape being read by INPUTT1 to a tape to be written by ØUTPUT1.

The third parameter (P3) for this module is used to define the User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Written
+n	No
0	No
-1	Yes
-2	Yes (On New Reel)
-3	No (Warning Check)
-4	Yes (On New Reel)

The user may specify the third parameter as V, Y, name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

VII. EXAMPLES:

1. ØUTPUT1 A,B,,, // C,N,0 / C,N,0 $ or ØUTPUT1 A,B,,, // $

   Write data blocks A and then B onto user tape INPT starting wherever INPT is currently positioned. If this is the first write operation on INPT it must be preceded by ØUTPUT1 ,,,, // C,N,-1 $ which will automatically label the tape positioned at its beginning.

2. ØUTPUT1, ,,,, // C,N,-1 / C,N,0 $

   Rewind INPT and destroy any data blocks that were on INPT and write default value of P3 on tape as a label.

3. ØUTPUT1 A,,,, // C,N,-2 / C,N,2 / C,N,USERTPA $

   Mount a new reel of tape (with write ring) for INP2 and write USERTPA for user tape label and then data block A as the first file.

4. ØUTPUT1, ,,,, // C,N,-2 / C,N,2 / C,N,USERTPA $
   ØUTPUT1 A,,,, // C,N,0 / C,N,2 $

   This is equivalent to example 3.

5. ØUTPUT1 A,B,C,D,E // C,N,14 $

   Starting from the current position, skip forward 14 data blocks on INPT and write A,B,C,D, and E as the next five data blocks. The skip positioning feature cannot be used if the current position of INPT is forward of a just previously written data block end-of-file or before the tape is labeled.

6. ØUTPUT1, ,,,, // C,N,-3 $ THIS IS AN
   ØUTPUT1 A,B,C,D,E // C,N,14 $ IMPRØPER EXAMPLE.

   This is an invalid sequence since the first call positions the tape at the end of all data blocks on the tape. See example 7.

7. INPUTT1 / ,,,, / C,N,-3 $
   ØUTPUT1 A,B,C,D,E // C,N,14 $

   A complete list of data block names will be printed by INPUTT1 which will then rewind the tape. Then, ØUTPUT1 will skip forward 14 data blocks and write A,B,C,D, and E. The user tape label is given a warning check by INPUTT1.

8. ØUTPUT1, ,,,, // C,N,-2 $ THIS IS AN
   ØUTPUT1, ,,,, // C,N,-3 $ IMPRØPER EXAMPLE.
   ØUTPUT1, A,B,,, // C,N,14 $

   This is an invalid sequence since the first call effectively destroys whatever information is on the tape. See example 9.

9. INPUTT1 / ,,,, / C,N,-2 $
INPUTT1 / ,,,, / C,N,-3 $
ØUTPUT1 A,B,,, // C,N,14 $

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and rewind the tape. Skip 14 data blocks on the tape and write A and then B as the 15^{th} and 16^{th} data blocks. Any information forward of this current position is effectively destroyed. See example 10.

10. INPUTT1 / ,,,, / C,N,-2 $
ØUTPUT1 A,B,,, // C,N,-3 $

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and write A and B as new data blocks at the end of the tape. If INPT contained 14 data blocks at the start of this sequence, it would be more efficient to do it this way than by using the sequence of example 9 since a pass on the tape is eliminated.

11. INPUTT1 / ,,,, / C,N,-2 / C,N,0 / V,Y,BDSETLAB $
ØUTPUT1 A,B,,, // C,N,-3 / C,N,0 / V,Y,BDSETLAB $

This is equivalent to example 10 except the user tape label is set on a PARAM card which must be included in the BULK DATA deck (i.e., PARAM BDSETLAB USERTP12).

VIII. MØRE DIFFICULT EXAMPLES USING BØTH INPUTT1 AND ØUTPUT1:

Example 1:

(a) Objectives:

(1) Obtain printout of the names of all data blocks on INPT.

(2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.

(3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

```
BEGIN $                                  (1)
INPUTT1 / ,,,, / C,N,-3 $                (2)
INPUTT1 / ,,T1,T2,T3 / C,N,6 $           (3)
INPUTT1 / ,,,, / C,N,-1 $                (4)
ØUTPUT1 A,B,T1,T2,T3 // C,N,4 $          (5)
ØUTPUT1, ,,,, // C,N,-3 $                (6)
END $
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.

(2) DMAP sequence (3) recovers data blocks 7,8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.

(3) DMAP sequence (4) rewinds INPT.

(4) DMAP sequence (5) accomplishes objective (2).

(5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.

(6) Note that INPUTT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

Example 2:

(a) Objectives:

(1) Write data blocks A, B, and C on INPT.

(2) Obtain printout of the names of all data blocks on INPT after step (1).

(3) Make two copies of the tape created in (1).

(4) Add data blocks D and E to one of the tapes.

(5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                                 (1)
ØUTPUT1 A,B,C,, // C,N,-1 $             (2)
ØUTPUT1, ,,,, // C,N,-3 $               (3)
ØUTPUT1 A,B,C,, // C,N,-2 $             (4)
ØUTPUT1 A,B,C,, // C,N,-2 $             (5)
ØUTPUT1 D,E,,, // $                     (6)
ØUTPUT1, ,,,, // C,N,-3 $               (7)
END $                                   (8)
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) since the tape must initially have P3 written on it when first used. The DMAP statement ØUTPUT1 A,B,C,, // C,N,-1 $ will accomplish the same thing.

(2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(3) Statements (4) and (5) accomplish objective (3).

(4) Statement (6) accomplishes objective (4) where the third tape is used.

(5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 $ will do the same thing and add a rewind.

(6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1 A,B,C,, // C,N,-1 $
ØUTPUT1, ,,,, // C,N,-3 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1 D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1, ,,,, // C,N,-3 / C,N,2 $
END $
```

I. NAME: ØUTPUT2 (Create User Written FØRTRAN Tapes)
(The companion module is INPUTT2)

II. PURPØSE: Writes up to five data blocks and a user tape label onto a FØRTRAN-written user tape for subsequent use at a later date. ØUTPUT2 is also used to position the user tape prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written. The user is cautioned to be careful when positioning a user tape with ØUTPUT2 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.

III. DMAP CALLING SEQUENCE:

ØUTPUT2 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:

DBi - Any data block which the user desires to be written on one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.

V. ØUTPUT DATA BLØCKS: None.

VI. PARAMETERS:

The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing.
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-9	Write a final EØF on the tape.

The second parameter (P2) for this module is the FØRTRAN unit number onto which the data blocks will be written. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine or installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used to define the FØRTRAN User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Table Label Written
+n	No
0	No
-1	Yes
-3	No (Warning Check)
-9	No

The user may specify the third parameter as V,Y,name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

VII. EXAMPLES:

ØUTPUT2 is intended to have the same logical action as the GINØ User Tape module ØUTPUT1 except for tape reel switching. It is therefore suggested that the examples shown under module ØUTPUT1 be used for ØUTPUT2 as well, excepting the ones involving tape reel switching. All examples should be ended with a call to ØUTPUT2 with P1 = -9.

VIII. REMARKS:

The primary objective of this module is to write tapes using simple FØRTRAN so that a user can read NASTRAN generated data with his own program. Similarly, matrices can be generated with externally written simple FØRTRAN programs and then read by module INPUTT2.

In order to do this, the format of the information on these tapes must be adhered to. The basic idea is that a one word logical KEY record is written which indicates what follows. A zero value indicates an end-of-file condition. A negative value indicates the end of a record where the absolute value is the record number. A positive value indicates that the next record consists of that many words of data.

The correspondence between FØRTRAN records and GINØ-written NASTRAN files is shown in the following sample:

FØRTRAN Record	Length	Contents	NASTRAN File	File Record
1	1	KEY > 0	1	1
2	KEY	{Data} KEY		
3	1	KEY > 0		
4	KEY	{Data} KEY		
5	1	KEY < 0 (EØR)		
6	1	KEY > 0		2
7	KEY	{Data} KEY		
8	1	KEY < 0 (EØR)		
9	1	KEY = 0 (EØF)		EØF
10	1	KEY > 0	2	1
11	KEY	{Data} KEY		
12	1	KEY < 0 (EØR)		
13	1	KEY = 0 (EØF)		EØF
14	1	KEY = 0 (EØF=EØD)	3	EØF

I. NAME: ØUTPUT3 (Punch Matrix Data Blocks onto Cards)

II. PURPØSE: Punches up to five matrix data blocks onto DMI bulk data cards. These cards may then read into NASTRAN as ordinary bulk data to reestablish the matrix data block at a later date.

III. DMAP CALLING SEQUENCE:

```
ØUTPUT3  M1,M2,M3,M4,M5 // C,N,P1 / C,Y,N1=ABC / C,Y,N2=DEF / C,Y,N3=GHI /
                              C,Y,N4=JKL / C,Y,N5=MNØ $
```

IV. INPUT DATA BLØCKS:

Mi - Any matrix data block which the user desires to be punched on DMI cards. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be punched.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

The first parameter (P1) controls the writing of the DMI card images on a FØRTRAN unit as follows:

$P1 < 0$ write on FØRTRAN unit $|P1|$ as well as punch DMI cards

$P1 \geq 0$ punch DMI cards only

The default value for P1 is 0.

Ni - The values of the five BCD parameters shown above are used to create a unique continuation field configuration on the DMI cards. Only the first three characters are used. These three characters must be unique for all matrices which will be input together during a subsequent run using cards generated by ØUTPUT3. (Input, BCD, default values are N1 = no default, N2=N3=N4=N5=XXX).

VII. METHØD: The nonzero elements of each matrix are punched on double-field DMI cards as shown in the example below. The name of the matrix is obtained from the header record of the data block. Field 10 contains the three character parameter value in columns 74-76 and an incremented integer card count in columns 77-80.

VIII. EXAMPLE:

Let the data block MAT contain the matrix

$$[MAT] = \begin{bmatrix} 1.0 & 0.0 & 6.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 7.0 & 0.0 & 0.0 & 0.0 \\ 2.0 & 4.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 5.0 & 0.0 & 0.0 & 0.0 & 9.0 \\ 3.0 & 0.0 & 8.0 & 0.0 & 0.0 & 0.0 \end{bmatrix}$$

The DMAP instruction OUTPUT3 MAT,,,, // C,N,0 / C,N,XYZ $ will then punch out the DMI cards shown below.

DMI	MAT	0	2	1	2		5	6	+XYZ 0

DMI*	MAT	1	1	1.000000E 00	*XYZ 1
*XYZ 1	3	2.000000E 00	5	3.000000E 00	*XYZ 2
DMI*	MAT	2	3	4.000000E 00	*XYZ 3
*XYZ 3	5.000000E 00				*XYZ 4
DMI*	MAT	3	1	6.000000E 00	*XYZ 5
*XYZ 5	7.000000E 00	5	8.000000E 00		*XYZ 6
DMI*	MAT	6	4	9.000000E 00	*XYZ 7

IX. REMARKS:

1. Only real single- or double-precision matrices may be output.

2. All matrices are output on double-field cards in single-precision.

3. The maximum number of cards that may be punched is 9999. If matrices larger than this are desired, use module ØUTPUT2 and write a program to process the resulting FØRTRAN file.

4. The auxiliary subroutine PHDMIA used by module ØUTPUT3 can be used with stand-alone FØRTRAN programs. See Section 4 of the Programmer's Manual for details.

I. NAME: PARAM (Parameter Processor)

II. PURPOSE: To perform specified operations on integer DMAP parameters.

III. DMAP CALLING SEQUENCE:

PARAM // C,N,op / V,N,ØUT / V,N,IN1 / V,N,IN2 $

IV. INPUT DATA BLOCKS: None

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. op is a BCD operation code from the table below (Input, no default). Op is usually specified as a "C,N" parameter.
2. ØUT is the name of the parameter which is being generated by PARAM (output, integer, default = 1).
3. IN1 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).
4. IN2 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).

VII. REMARKS:

1. The table below gives the results for ØUT as a function of op, IN1, and IN2.

Arithmetic Operations					
op	ADD	SUB	MPY	DIV	NØT
ØUT	IN1+IN2	IN1-IN2	IN1·IN2	IN1/IN2	-IN1

Logical Operations												
op	AND				ØR				IMPL			
ØUT	-1	+1	+1	+1	-1	-1	-1	+1	-1	+1	-1	-1
IN1	<0	<0	≥ 0	≥ 0	<0	<0	≥ 0	≥ 0	<0	<0	≥ 0	≥ 0
IN2	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0	<0	≥ 0

Special Operations	
op	ØUT
NOP	ØUT (unchanged)
KLØCK	Current CPU time in integer seconds from the start of the job.
TMTØGØ	Remaining CPU time in integer seconds based on the TIME card.
PREC	Returns the currently requested precision; 2 = D.P. , 1 = S.P.

2. PARAM does its own SAVE; therefore, a SAVE is not needed following the module.

VIII. EXAMPLES:

1. PARAM // C,N,NØT / V,N,XYZ / V,N,NØXYZ $ - this example changes the sense of parameter NØXYZ which may be useful for the CØND or EQUIV instructions. Alternatively, XYZ could have been set in the following way:

2. PARAM // C,N,MPY / V,N,XYZ / V,N,NØXYZ / C,N,-1 $

3. PARAM // C,N,IMPL / V,N,ABC / V,N,DEF / V,N,GHI $

4. PARAM // C,N,NØP / V,N,P1=5 $ - this example sets the value of parameter P1 to 5 and saves it for subsequent use.

I. NAME: PARAML (Selects parameters from a list)

II. PURPOSE: To select parameters from a user input matrix or table.

III. DMAP CALLING SEQUENCE:

```
PARAML   INPUT // C,N,ØP / V,N,RECNØ / V,N,WØRDN /
         V,N,REAL1 / V,N,INTEG / V,N,REAL2 / V,N,BCD $
```

IV. INPUT DATA BLOCKS:

INPUT - Any matrix or table

V. OUTPUT DATA BLOCKS:

None.

VI. PARAMETERS:

ØP - Input-BCD-no default.

RECNØ - Input-integer-default = 1

WØRDN - Input-integer-default = 1

REAL1 - Output-real-default = 1.0

INTEG - Output-integer-default = 0

REAL2 - Output-real-default = 1.0

BCD - Output-BCD-default = blank

VII. REMARKS:

1. REAL1, INTEG, REAL2, and BCD will be set by the module whenever they are "V" type parameters.

2. RECNØ and WØRDN control the starting point, according to ØP.

   If ØP = DMI, RECNØ is the column number and WØRDN is the row number.
   If ØP = DTI, RECNØ is the record number and WØRDN is the word number.
   If ØP = PRESENCE, INTEG will be -1 if INPUT is purged.

3. PARAML does its own SAVE; therefore, a SAVE is not needed following the module.

VIII. EXAMPLE:

Obtain the value in column 1, row 1 of a matrix.

```
PARAML   KGG // C,N,DMI / C,N,1 / C,N,1 / V,N,TERM $
```

I. NAME: PARAMR (Parameter Processor - Real)

II. PURPOSE: To perform specified arithmetic, logical, and conversion operations on real or complex parameters.

III. DMAP CALLING SEQUENCE:

```
PARAMR   // C,N,ØP / V,N,ØUTR / V,N,INR1 / V,N,INR2 /
                     V,N,ØUTC / V,N,INC1 / V,N,INC2 /
                     V,N,FLAG $
```

IV. INPUT DATA BLOCKS:

None.

V. OUTPUT DATA BLOCKS:

None.

VI. PARAMETERS:

ØP	-	Input-BCD operation code from the table below - no default
ØUTR	-	Output-real-default = 0.0
INR1	-	Input-real-default = 0.0
INR2	-	Input-real-default = 0.0
ØUTC	-	Output-complex-default = (0.0,0.0)
INC1	-	Input-complex-default = (0.0,0.0)
INC2	-	Input-complex-default = (0.0,0.0)
FLAG	-	Output-integer-default = 0

The values of the parameters are dependent upon ØP as shown in the following table:

ØP	OUTPUTS
ADD	ØUTR = INR1 + INR2
SUB	ØUTR = INR1 - INR2
MPY	ØUTR = INR1 * INR2
DIV	ØUTR = INR1 / INR2
NØP	RETURN
SQRT	ØUTR = $\sqrt{\text{INR1}}$
SIN	ØUTR = SIN(INR1)
CØS	ØUTR = COS(INR1)
ABS	ØUTR = $\lvert$ INR1 $\rvert$
EXP	ØUTR = exp (INR1)

DMAP MODULE DESCRIPTIONS

TAN	ØUTR = TAN(INR1)
NØRM	ØUTR = || ØUTC ||
PØWER	ØUTR = INR1 ** INR2
ADDC	ØUTC = INC1 + INC2
SUBC	ØUTC = INC1 - INC2
MPYC	ØUTC = INC1 * INC2
DIVC	ØUTC = INC1 / INC2
CSQRT	ØUTC = $\sqrt{\text{INC1}}$
CØMPLEX	ØUTC = (INR1,INR2)
CØNJ	ØUTC = $\overline{\text{INC1}}$
REAL	INR1 = Re (ØUTC)
	INR2 = Im (ØUTC)
EQ	FLAG = -1 if INR1 = INR2
GT	FLAG = -1 if INR1 INR2
LT	FLAG = -1 if INR1 INR2
LE	FLAG = -1 if INR1 INR2
GE	FLAG = -1 if INR1 INR2
NE	FLAG = -1 if INR1 ≠ INR2
LØG	ØUTR = LØG_{10} (INR1)
LN	ØUTR = LØG_{e} (INR1)
FIX	FLAG = FIX (ØUTR)
FLØAT	ØUTR = FLØAT(FLAG)

VII. REMARKS:

1. Any output parameter must be "V" type if the parameter is used by "ØP" as output.
2. For ØP = DIV or ØP = DIVC, the output is zero if the denominator is zero.
3. PARAMR does its own SAVE; therefore, a SAVE is not needed following the module.
4. For ØP = SIN or ØP = CØS, the input must be expressed in radians.

I. NAME: PRTPARM (Parameter and DMAP Message Printer)

II. PURPØSE: A. Prints parameter values.

B. Prints DMAP messages.

III. DMAP CALLING SEQUENCE:

PRTPARM // C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

a - Integer value (no default value)

b - BCD value (default value = XXXXXXXX)

c - Integer value (default value = 0)

VII. METHØD:

A. As a parameter printer, use a = 0. There are two options:

1. b = parameter name will cause the printout of the value of that parameter.

   Example: PRTPARM // C,N,0 / C,N,LUSET $

2. b = XXXXXXXX will cause the printout of the values of all parameters in the current variable parameter table. Since this is the default value, it need not be specified.

   Example: PRTPARM // C,N,0 $

B. As a DMAP message printer, use $a \neq 0$. There are two options:

1. $a > 0$ causes the printout of the j^{th} message of category b where $j=|a|$ and b is one of the values shown below. (The number of messages available in each category is also given.)

   Example: PRTPARM // C,N,1 / C,N,DMAP $

2. $a < 0$ causes the same action as $a > 0$ with the additional action of program termination. Thus, PRTPARM may be used as a fatal message printer.

   Example: PRTPARM // C,N,-2 / C,N,PLA $

VIII. REMARKS:

1. b is always a value.

2. Meaningless values of a and b will result in diagnostic messages from PRTPARM.

3. TABLE OF b CATEGORY VALUES

	Rigid Format	Value of b	Number of Messages
1	Static Analysis	STATICS	5
2	Static Analysis with Inertia Relief	INERTIA	5
3	Normal Mode Analysis	MØDES	3
4	Static Analysis with Differential Stiffness	DIFFSTIF	6
5	Buckling Analysis	BUCKLING	6
6	Piecewise Linear Analysis	PLA	5
7	Direct Complex Eigenvalue Analysis	DIRCEAD	3
8	Direct Frequency and Random Response	DIRFRRD	4
9	Direct Transient Response	DIRTRD	3
10	Modal Complex Eigenvalue Analysis	MDLCEAD	4
11	Modal Frequency and Random Response	MDLFRRD	6
12	Modal Transient Response	MDLTRD	5
	DMAP	DMAP	See Remark 5

4. For details on error messages for the i^{th} Rigid Format see section 3.(i + 1).2 in the User's Manual.

5. The message number, a, may be any integer for DMAP messages.

6. The third parameter is not currently used.

DIRECT MATRIX ABSTRACTION

I. NAME: SEEMAT (Pictorial Matrix Printer)

II. PURPØSE: Shows nonzero matrix elements on printer or plotter output positioned pictorially by row and column within the outlines of the matrix.

III. DMAP CALLING SEQUENCE:

SEEMAT M1,M2,M3,M4,M5 // C,N, $\left\{\frac{\text{PRINT}}{\text{PLØT}}\right\}$ / V,N,PFILE / V,N,PACK / C,N,plotter /

C,N,modeln1 / C,N,modelb1 / C,N,modeln2 / C,N,modelb2 /

C,N,sizex / C,N,sizey $

IV. INPUT DATA BLØCKS:

Matrix Data Blocks, any of which may be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. PRINT implies use of the system output file. (Any value other than PLØT implies PRINT.)

   PLØT implies use of one of the plotters. Either of the plotter tapes PLT1 or PLT2 will be used, depending on the type of plotter requested (see Section 4.1).

   The default value for the first parameter is PRINT.

2. PFILE is the Plot File Number. (Used only if first parameter is PLØT.)

   Input/output variable integer parameter. Frame or sheet number. The value of this parameter will be incremented by one (1) for each frame (sheet) plotted by SEEMAT.

   The default value for the second parameter is 0.

3. PACK is reserved for a future modification that will allow the representation of a nonzero block of the matrix with a single character.

   The default value for the third parameter is 100.

4. Plotter Name - If the first parameter = PLØT, one of the plotter names must be selected from the following list. Additional information on plotters and the meaning of the symbols used below is given in Section 4. The associated model identifiers are specified with the next four parameters. Each plotter has a default model associated with it, as indicated by the underlined model identifier.

   The default value for the fourth parameter is SC.

Plotter Name	Model Identifiers
BL	LTE,30 STE,30
EAI	3500,30 3500,45
SC	4020,0
CALCØMP	765,205 765,210 765,105 765,110 763,205 763,210 763,105 763,110 565,205 565,210 565,105 565,110 565,305 565,310 563,205 563,210 563,105 563,110 563,305 563,310
DD	80,B
NASTRAN	M,0 T,0 D,0 M,1 T,1 D,1

5. The parameter modeln1 is used to specify the first of the two model identifiers when it is an integer value. The default value for the fifth parameter is 0.

6. The parameter modelb1 is used to specify the first of the two model identifiers when it is a BCD value. The default value for the sixth parameter is blank.

7. The parameter modeln2 is used to specify the second of the two model identifiers when it is an integer value. The default value for the seventh parameter is 0.

8. The parameter modelb2 is used to specify the second of the two model identifiers when it is a BCD value. The default value for the eighth parameter is blank.

9. The parameter sizex specifies the size of the plotter surface x-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizex is 30.0.

10. The parameter sizey specifies the size of the plotter surface y-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizey is 30.0.

VII. METHØD: The matrix is partitioned into blocks which can be printed on a single sheet of output paper or frame on the plotter selected. Only blocks containing nonzero elements will be output. Row and column indices are indicated. The user of this module is cautioned to make sure his line count limit is large enough. A default of 20,000 lines is provided by NASTRAN. This may be changed via the statement MAXLINES= value in the NASTRAN Case Control Deck. The transpose of the matrix is output.

VIII. REMARKS:

1. If a plotter is used, the appropriate tape must be made available to NASTRAN.
2. If a plotter is used, a SAVE instruction should be executed to update PFILE.
3. The nonzero elements are indicated by asterisks (*), except for diagonal elements of square matrices which are indicated by the letter D, and elements in the last row or column which are indicated by dollar signs ($).
4. The default model for any plotter is specified by omitting the last four parameters.
5. When two of the last four parameters are used to specify model identifiers, the remaining two parameters should be specified as C,N only.

IX. EXAMPLES :

1. Specify CALCØMP 765,205 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,CALCØMP $
```

2. Specify EAI 3500,45 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,EAI / C,N,3500 / C,N /
                          C,N,45 / C,N $
```

3. Specify Benson Lehner STE,30 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,BL / C,N / C,N,STE /
                          C,N,30 / C,N $
```

4. Specify the printer rather than a plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // $
```

5. For additional examples see Section 5.4.8.

I. NAME: SETVAL (Set Values)

II. PURPØSE: Set DMAP Parameter variable values equal to other DMAP Parameter variables or DMAP Parameter constants.

III. DMAP CALLING SEQUENCE:

```
SETVAL  // V,N,X1 / V,N,A1 /
           V,N,X2 / V,N,A2 /
           V,N,X3 / V,N,A3 /
           V,N,X4 / V,N,A4 /
           V,N,X5 / V,N,A5 $
```

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

X1, X2, X3, X4, X5	Output, integers, variables
A1, A2, A3, A4, A5	Input, integers; default values = 1, variables or constants.

VII. METHØD: This module sets X1 = A1, X2 = A2, X3 = A3, X4 = A4, and X5 = A5. Only two parameters need be specified in the calling sequence (X1 and A1).

VIII. REMARKS:

1. A SAVE instruction must immediately follow the SETVAL instruction if the output parameter values are to be subsequently used.
2. See PARAM for an alternate method of defining parameter values.
3. As an example, the statements

```
SETVAL  // V,N,X1 / V,N,A1 / V,N,X2 / C,N,3 $
SAVE    X1,X2 $
```

are equivalent to the statements

```
PARAM  // C,N,ADD / V,N,X1 / V,N,A1 / C,N,0 $
PARAM  // C,N,NØP / V,N,X2=3 $
```

I. NAME: TABPCH (Table Punch)

II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.

III. DMAP CALLING SEQUENCE:

TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 $

IV. INPUT DATA BLOCKS:

TAB1
TAB2
TAB3 Any NASTRAN Tables
TAB4
TAB5

V. OUTPUT DATA BLOCKS:

None - All output is punched onto DTI cards.

VI. PARAMETERS:

A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.

VII. REMARKS:

1. Any or all tables may be purged.

2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.

3. Up to 99,999 cards may be punched per table.

4. Currently, twice the entire record must fit in open core.

5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.

VIII. EXAMPLES:

TABPCH EST,,,,.// C,N,ES $ will punch the EST onto cards with a continuation neumonic of $+ES_{bbbb}i$ (where i is the sequence number).

DMAP MODULE DESCRIPTIONS

I. <u>NAME</u>: TABPRT (Formatted Table Printer)

II. <u>PURPOSE</u>: To print selected table data blocks with format for ease of reading.

III. <u>DMAP CALLING SEQUENCE</u>:

TABPRT TDB // C,N,KEY / C,N,ØPT1 / C,N,ØPT2 $

IV. <u>INPUT DATA BLOCKS</u>:

TDB - Table Data Block from list given under X.

V. <u>ØUTPUT DATA BLOCKS</u>: None

VI. <u>PARAMETERS</u>:

1. KEY - Alphanumeric value, no default. Identifies the format to be used in printing the table. The allowable list is given under X.
2. ØPT1 - Integer, default value = 0. If 0, no blank lines are written between entires. If ≠ 0, one blank line will be written between each entry.
3. ØPT2 - Integer, default value = 0. Not used at present.

VII. <u>ØUTPUT</u>:

The contents of the table are formatted and written on the system output file.

VIII. <u>NØTES:</u>

1. The module returns in the event of any difficulty.
2. The TABPT module can be used to print the contents of <u>any</u> data block.

IX. <u>EXAMPLES</u>:

1. TABPRT CSTM // C,N,CSTM $
2. TABPRT GPL // C,N,GPL / C,N,1 $

X. MISCELLANEØUS

List of data blocks recognized by TABPRT (Rigid Format name used here. The actual DMAP name for the same or equivalent information is acceptable.)

Data Block	Key (Value)
BGPDT	BGPDT
CSTM	CSTM
EQDYN	EQDYN
EQEXIN	EQEXIN
GPCT	GPCT
GPDT	GPDT
GPL	GPL
GPLD	GPLD
GPTT	GPTT

I. NAME: TABPT (Table Printer)

II. PURPØSE: To print table data blocks (may be used for matrix data blocks if desired).

III. DMAP CALLING SEQUENCE:

TABPT TAB1,TAB2,TAB3,TAB4,TAB5 // $

IV. INPUT DATA BLØCKS:

TAB1 -
TAB2 -
TAB3 - Any NASTRAN data block.
TAB4 -
TAB5 -

Note: Any or all input data blocks can be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. REMARKS:

1. Each input data block is treated as a table and its contents are printed on the system output file via a prescribed format. Each word of the table is identified by the module as to type (real, BCD, integer) and an appropriate format is used.
2. The trailer data items for the table are also printed.
3. Purged input data blocks are not printed.

VIII. EXAMPLES:

TABPT GEØM1,,,, // $

TABPT GEØM1,GEØM2,GEØM3,GEØM4,GEØM5 // $

I. NAME: TIMETEST (Provides Timing Data)

II. PURPOSE: To produce timing data for specific NASTRAN unit operations.

III. DMAP CALLING SEQUENCE:

TIMETEST /, / C,N,N / C,N,M / C,N,T / C,N,Ø1 / C,N,Ø2 $

IV. INPUT DATA BLOCKS: None

V. OUTPUT DATA BLOCKS:

FILE1
FILE2 Reserved for future implementation

VI. PARAMETERS

N - Outer Loop Index

M - Inner Loop Index

T - Data type to be processed

Ø1 - TIMTST Routine to be processed

Ø2 - Powers of two table for TIMTS1 option selection

See Section 4.127 of the NASTRAN Programmer's Manual for further description of the parameters.

VII. REMARKS

None.

VIII. EXAMPLES

TIMETEST / , / C,N,100 / C,N,100 / C,N,1 / C,N,2 $

TIMETEST / , / C,N,10 / C,N,10 / C,N,3 / C,N,1 / C,N,127 $

DIRECT MATRIX ABSTRACTION

I. NAME: VEC (Creates partitioning vector based on USET).

II. PURPØSE: To create a partitioning vector for displacement method matrices using USET that may be used by Matrix Operation Modules MERGE and PARTN. This allows the user to split up long running modules such as SMP1.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or prior to module GKAD (or GKAM) in Rigid Formats 7-12:

```
VEC  USET / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

```
VEC  USETD / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

IV. INPUT DATA BLØCKS:

USET - U-set

or

USETD - U-set (Dynamics)

Note: U-set may not be missing and must fit into open core.

V. ØUTPUT DATA BLØCKS:

V - Partitioning vector.

Note: 1. If all elements are in SET0 or SET1 then V will be purged.

2. V may not be purged prior to execution.

VI. PARAMETERS:

SET - Matrix set to be partitioned (Input ,BCD, no default.)

SET0 - Upper partition of SET (Input ,BCD, no default).

SET1 - Lower partition of SET (Input ,BCD, no default).

ID - Identification of bit position (see Remarks) (Input, integer, default = 0).

Note: 1. Legal parameter values are given in the table on page 5.3-17.

2. See Section 1.7.3 of the Programmer's Manual for a description of set notation or Section 3.3 of the Theoretical Manual.

VII. REMARKS:

1. Parameters SET0 and SET1 must be a subset of the SET matrix parameter. A degree of freedom may not be in both subsets.

2. If desired, one of SET0 or SET1 but not both may be requested to be the complement of the other one by giving it a value of CØMP.

3. If SET = BITID, the second and third parameters are ignored and the IDth bit position in USET (or USETD) is used. In this case, SET is assumed equal to G (or P) and SET0 will correspond to the zero's in the IDth position and SET1 will correspond to the non-zero's in the IDth position.

VIII. EXAMPLES:

1. To partition [K_{ff}] into a- and o- set based matrices, use

```
VEC   USET / V / C,N,F / C,N,Ø / C,N,A $

PARTN KFF,V, / KØØ,KAØ,KØA,KAA $
```

Note that the same thing can be done in one step by

```
UPARTN USET,KFF / KØØ,KAØ,KØA,KAA / C,N,F / C,N,Ø / C,N,A $
```

2. Example 1 could be accomplished by

```
VEC  USET / V / C,N,F / C,N,Ø / C,N,CØMP $
```

or

```
VEC  USET / V / C,N,F / C,N,CØMP / C,N,A $
```

3. Example 1 could be accomplished by

```
VEC  USET / V / C,N,BITID / C,N,X / C,N,X / C,N,25 $
```

5.3.3 User Modules

Module	Page
DDR	5.3-29
DUMMØD1	5.3-30
DUMMØD2	5.3-31
DUMMØD3	5.3-32
DUMMØD4	5.3-33
INPUTT3	5.3-37
INPUTT4	5.3-38
MØDA	5.3-39
MØDB	5.3-40
MØDC	5.3-41
ØUTPUT	5.3-42
ØUTPUT4	5.3-46
PARTVEC	5.3-46a
XYPRNPLT	5.3-47

A number of modules have been placed in the NASTRAN system for which only dummy code exists. These modules are available to the user who wishes to create his own data blocks by reading tapes or data cards, generate his own output on the printer, punch or plotter, or perform his own matrix computations. The appropriate MPL information is presented for each such user module in this section. All necessary interfaces with the Executive System have been completed for these user modules. The procedures for implementing a user module are described in Section 2 of the Programmer's Manual.

I. NAME: DDR (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS below)

```
DDR  A,B,C,D,E,F,G,H,I,J,K,L,M / X,Y,Z / C,N,ABC / C,N,DEF / C,N,GHI / C,N,0 /
     C,N,0 / C,N,0 / C,N,0 $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs, as well as the number, type, and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of the Programmer's Manual).

I. NAME: DUMMØD1 (Dummy Module - 1)*

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD1   I1,I2,I3,I4,I5,I6,I7,I8 /
          Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
          C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
          C,Y,P5=-1.0 / C,N,-1.0 /
          C,Y,P7=ABCDEFGH /
          C,Y,P8=-1.0D0 /
          C,Y,P9=(-1.0,-1.0) /
          C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

*The delivery version of NASTRAN contains a DUMMØD1 module which is used to compute timing constants for the various machines on which the program runs.

I. NAME: DUMMØD2 (Dummy Module - 2)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD2  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: DUMMØD3 (Dummy Module - 3)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD3  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: DUMMØD4 (Dummy Module - 4)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS)

```
DUMMØD4  I1,I2,I3,I4,I5,I6,I7,I8 /
         Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
         C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
         C,Y,P5=-1.0 / C,N,-1.0 /
         C,Y,P7=ABCDEFGH /
         C,Y,P8=-1.0D0 /
         C,Y,P9=(-1.0,-1.0) /
         C,Y,P10=(-1.0D0,-1.0D0) $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

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I. NAME: INPUTT3 (Auxiliary Input File Processor)

II. PURPØSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.

III. DMAP CALLING SEQUENCE:

INPUTT3 I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: Any or all of the inputs may be purged according to the user-writer's design.

V. ØUTPUT DATA BLØCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.

VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.

VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

I. NAME: INPUTT4 (Auxiliary Input File Processor)

II. PURPØSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.

III. DMAP CALLING SEQUENCE:

INPUTT4 I1,I2,I3,I4,I5 / Ø1,Ø2,Ø3,Ø4,Ø5 / C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: Any or all of the inputs may be purged according to the user-writer's design.

V. ØUTPUT DATA BLØCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.

VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.

VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

I. NAME: *MØDA (User Dummy Module)*

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

```
MØDA  / W,X,Y,Z / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0 /
        C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0.0 / C,N,0 / C,N,0 $
```

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: MØDB (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

```
MØDB  A,B,C / W,X,Y,Z / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,0 / C,N,0 / C,N,0 /
                C,N,1.0 / C,N,0 / C,N,0 / C,N,0 $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: MØDC (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

MØDC A,B // C,N,-1 $

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: ØUTPUT (Auxiliary Output File Processor)

II. PURPØSE: A user-written module to generate printer, plotter or punch output.

III. DMAP CALLING SEQUENCE: (see remark under METHØD)

ØUTPUT IN // C,Y,P=-1 $

IV. INPUT DATA BLØCKS:

IN - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.

VII. METHØD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

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I. NAME: ØUTPUT4 (Auxiliary Output File Processor)

II. PURPØSE: A user-written module to generate printer, plotter or punch output.

III. DMAP CALLING SEQUENCE: (see remark under METHØD)

ØUTPUT4 IN1,IN2,IN3,IN4,IN5 // V,N,P1=-1 / V,N,P2=-1 $

IV. INPUT DATA BLØCKS:

INi - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.

VII. METHØD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: PARTVEC (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (See REMARKS below)

```
PARTVEC  I01,I02,---,I20,I21 / Ø1,Ø2,Ø3 / V,N,P1=0 / V,N,P2=0 / --- / V,N,P22=0 $
```

IV. INPUT DATA BLØCKS: As desired by author of module.

V. ØUTPUT DATA BLØCKS: As desired by author of module.

VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the values shown in the calling sequence shown above.

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

I. NAME: XYPRNPLT (User Dummy Module)

II. PURPØSE: Can be used for any desired purpose.

III. DMAP CALLING SEQUENCE: (see REMARKS below)

XYPRNPLT A// $

IV. INPUT DATA BLØCKS: As desired by the author of module.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS: None

VII. REMARKS:

This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section of Programmer's Manual).

5.3.4 Executive Operation Modules

Module	Basic Function	Page
BEGIN	Always first in DMAP	5.3-49
CHKPNT	Write data blocks on checkpoint tape if checkpointing	5.3-50
CØND	Conditional forward jump	5.3-51
END	Always last in DMAP; terminates DMAP execution	5.3-52
EQUIV	Assign another name to a data block	5.3-53
EXIT	Conditional DMAP termination	5.3-54
FILE	Defines special data block characteristics to DMAP compiler	5.3-55
JUMP	Unconditional forward jump	5.3-56
LABEL	Defines DMAP location	5.3-57
PURGE	Conditional data block elimination	5.3-58
REPT	Repeat a series of DMAP instructions	5.3-59
SAVE	Save value of output parameter	5.3-60

All modules classified as Executive Operation Modules are individually described in this section. Additional discussions concerning the interaction of the Executive Modules with themselves and with the NASTRAN Executive System are contained in Section 5.2.3.

I. NAME: BEGIN (Begin DMAP program)

II. PURPØSE: BEGIN Is a declarative DMAP instruction which denotes the beginning of a DMAP program.

III. DMAP CALLING SEQUENCE:

BEGIN $

IV. REMARKS:

1. The BEGIN card is required when selecting APP DMAP in the Executive Control Deck and must be followed by DMAP instructions up to and including the END card.
2. BEGIN is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

I. NAME: CHKPNT (Checkpoint)

II. PURPØSE: Causes data blocks to be written on the New Problem Tape (NPTP) to enable the problem to be restarted with a minimum of redundant processing.

III. DMAP CALLING SEQUENCE:

CHKPNT D1,D2,...,DN $

where D1,D2,...,DN ($N \geq 1$) are data blocks to be copied onto the problem tape for use in restarting problem.

IV. RULES:

1. A data block to be checkpointed must have been referenced in a previous PURGE, EQUIV or functional module instruction.
2. CHKPNT cannot be the first instruction of a DMAP loop.
3. Data Blocks generated by the Input File Processor (including DMI's and DTI's) should not be checkpointed since they are always regenerated on restart.
4. Checkpointing only takes place when a New Problem Tape (NPTP) is set up and the Executive Control Card CHKPNT YES appears in the Executive Control Deck. Otherwise, the CHKPNT instructions are ignored.
5. For each data block that is successfully checkpointed, a card of the restart dictionary is punched which gives the critical data for the data block as it exists on the Problem Tape.
6. For data blocks that have been purged or equivalenced, an entry is made in the restart dictionary to this effect. In these cases data blocks are not written on the Problem Tape.

I. NAME: CØND (Conditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by conditionally transferring program control to a specified location in the DMAP program.

III. DMAP CALLING SEQUENCE:

```
CØND  n,V $
```

where:

1. n is a BCD label name specifying the location where control is to be transferred. (See the LABEL instruction.)
2. V is a BCD name of a variable parameter whose value indicates whether or not to execute the transfer. If V < 0 the transfer is executed.

IV. EXAMPLE:

```
BEGIN $
  .
  .
  .
CØND  L1,K  $
MØDULE1  A/B/V,Y,P1  $
  .
  .
  .
LABEL  L1 $
MØDULEN  X/Y  $
  .
  .
  .
END $
```

If K ≥ 0, MØDULE1 is executed. If K < 0 control is transferred to the label L1 and MØDULEN is executed.

V. REMARKS:

Only forward transfers are allowed. See the REPT instruction for backward transfers.

I. NAME: END (End DMAP Program)

II. PURPØSE: Denotes the end of a DMAP program.

III. DMAP CALLING SEQUENCE:

END $

IV. NØTES:

1. The END instruction also acts as an implied EXIT instruction.
2. The END card is required whenever the analyst selects APP DMAP in his Executive Control Deck.

I. NAME: EQUIV (Data Block Name Equivalence)

II. PURPØSE: To attach one or more equivalent (alias) data block names to an existing data block so that the data block can be referenced by several equivalent names.

III. DMAP CALLING SEQUENCE:

EQUIV DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $

Note: The number of data block names (DBNij) prior to each parameter (PARMj) and the number of such groups in a particular calling sequence are variable.

IV. INPUT DATA BLØCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence. The 1st data block name in each group (DBN1A and DBN1B in the examples above) is known as the primary data block and the 2nd, etc. data block names become equivalent to the primary (depending on the associated parameter value). These equivalenced data blocks are known as secondary data blocks.

V. ØUTPUT DATA BLØCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each set of data block names.

VII. METHØD: The data block names in each group are made equivalent if the value of the associated parameter is < 0. If a number of data blocks are already equivalenced and the parameter value is ≥ 0, the equivalence is broken and the data block names again become unique. If the data blocks are not equivalenced and the parameter value is ≥ 0, no action is taken.

VIII. RULES:

1. The primary data block must be output from a previous functional module.
2. The primary data block must be referenced in the immediately preceding functional module and/or in a subsequent functional module.

I. NAME: EXIT (Terminate DMAP program)

II. PURPØSE: To conditionally terminate the execution of the DMAP program.

III. DMAP CALLING SEQUENCE:

EXIT c $

where c is an integer constant which specifies the number of times the instruction is to be ignored before terminating the program. If c = 0 the calling sequence may be shortened to EXIT $.

IV. EXAMPLE:

```
             BEGIN  $
               .
               .
               .
           ⎧ LABEL L1 $
           ⎪ MØDULE1 A/B/V,Y,P1 $
           ⎪   .
    DMAP   ⎨   .
    loop   ⎪   .
           ⎪ EXIT 3 $
           ⎩ REPT L1,3 $
               .
               .
               .
             END $
```

V. REMARKS:

1. The EXIT instruction will be executed the third time the loop is repeated (i.e., the instructions within the loop will be executed four times).
2. EXIT may appear anywhere within the DMAP sequence.

DMAP MODULE DESCRIPTIONS

I. NAME: FILE (File Allocation Aide)

II. PURPØSE: To inform the File Allocator (see Section 4.9 of the Programmer's Manual) of any special characteristics of a data block.

III. DMAP CALLING SEQUENCE:

FILE A=a1,a2...aα / B=b1,b2...bβ / .... / Z=z1,z2...zω $

where:

A,B...Z are the names of the data blocks possessing special characteristics.

a1...aα,b1...bβ....z1...zω are the special characteristics from the list below.

The allowable special characteristics are:

1. SAVE - Indicates data block is to be saved for possible looping in DMAP program.
2. APPEND - Output data blocks which are generated within a DMAP loop are rewritten during each pass through the loop, unless the data block is declared APPEND in a FILE statement. The APPEND declaration allows a module to add information to a data block on successive passes through a DMAP loop.
3. TAPE - Indicates that data block is to be written on a physical tape if a physical tape is available.

Notes:

1. Data blocks created by the NASTRAN preface may not appear in FILE declarations.
2. Symbolic DMAP sequences which explain the use of the FILE instruction are given in Section 5.2.3.1.
3. FILE is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.
4. A data block name may appear only once in all FILE statements; otherwise the first appearance will determine all special characteristics applied to the data block.

I. NAME: JUMP (Unconditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by unconditionally transferring program control to a specified location in the DMAP program. The normal order of execution of DMAP modules is the order of occurrence of the modules as DMAP instructions in the DMAP program.

III. DMAP CALLING SEQUENCE:

JUMP n $

where n is a BCD name appearing on a LABEL instruction which specifies where control is to be transferred.

IV. Remarks:

Jumps must be forward in the DMAP sequence. See the REPT instruction for backward jumps.

I. NAME: LABEL (DMAP Location)

II. PURPØSE: To label a location in the DMAP program so that the location may be referenced by the DMAP instructions JUMP, CØND and REPT.

III. DMAP CALLING SEQUENCE:

LABEL n $

where n is a BCD name.

IV. Remarks:

1. The LABEL instruction is inserted just ahead of the DMAP instruction to be executed when transfer of control is made to the label.

2. LABEL is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

I. NAME: PURGE (Explicit Data Block Purge)

II. PURPØSE: To flag a data block so that it will not be assigned to a physical file.

III. DMAP CALLING SEQUENCE:

PURGE DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB $

Note: The number of data block names (DBN_{ij}) prior to each parameter ($PARM_j$) and the number of groups of data block names and parameters in a particular calling sequence is variable.

IV: INPUT DATA BLØCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence.

V. ØUTPUT DATA BLØCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each group of data block names.

VII. METHØD: The data blocks in a group are purged if the value of the associated parameter is < 0. If a data block is already purged and the parameter value is ≥ 0, the purged data block is unpurged so that it may be subsequently reallocated. If the data block is not purged and the parameter value is ≥ 0, no action is taken.

I. NAME: REPT (Repeat)

II. PURPØSE: To repeat a group of DMAP instructions a specified number of times.

III. DMAP CALLING SEQUENCE:

REPT n,c $

where:

1. n is a BCD name which specifies the name of a label which marks the beginning of the group of DMAP instructions to be repeated. (See LABEL instruction).
2. c is an integer constant which specifies the number of times to repeat the instructions.

IV. EXAMPLE:

```
BEGIN $
  .
  .
  .
LABEL  L1  $
MØDULE1  A/B/V,Y,P1 $
   .
   .
   .
MØDULEN  B/C/V,Y,PN $
REPT  L1,3 $
  .
  .
  .
END $
```

V. REMARKS:

1. The instructions MØDULE1 to MODULEN will be repeated three times (i.e., executed four times) in the above example.
2. REPT is placed at the end of the group of instructions to be repeated.
3. The constant, c, may not be a parameter name.

I. NAME: SAVE (Save Variable Parameter Values)

II. PURPØSE: To specify which variable parameter values are to be saved from the preceding functional module DMAP instruction for use by subsequent modules.

III. DMAP CALLING SEQUENCE:

SAVE V1,V2,...,VN $

where the V1,V2,...,VN ($N > 0$) are the BCD names of some or all of the variable parameters which appear in the immediately preceding Functional Module DMAP instruction.

IV. REMARKS:

A SAVE instruction must immediately follow the functional module instruction wherein the parameters being saved are generated.

5.4 EXAMPLES

In order to facilitate the use of DMAP, several examples are provided in this section. The user is urged to study these examples both from the viewpoint of performing a sequence of matrix operations and that of a DMAP flow.

5.4.1 DMAP Example

Objective

1. Print the contents of table data block A.
2. Print matrix data blocks B,C, and D.
3. Print values of parameters P1 and P2.
4. Set parameter P3 equal to -7.

```
BEGIN     $
TABPT     A,,,, // $
MATPRN    B,C,D,, // $
PRTPARM   // C,N,0 / C,N,P1 $
PRTPARM   // C,N,0 / C,N,P2 $
PARAM     // C,N,NØP / V,N,P3=-7 $
END       $
```

Remarks:

To be a practical example, a restart situation is assumed. The user is cautioned to remember to reenter at DMAP instruction 2 by changing the last reentry point in the restart dictionary.

5.4.2 DMAP Example

Let the constrained stiffness matrix $[K_{\ell\ell}]$ and the load vector $\{P_\ell\}$ be defined by means of DMI bulk data cards. The following DMAP sequence will perform the series of matrix operations

$$\{u_1\} = [K_{\ell\ell}]^{-1}\{P_\ell\}$$

$$\{r\} = [K_{\ell\ell}]\{u_1\} - \{P_\ell\}$$

$$\{\delta u\} = [K_{\ell\ell}]^{-1}\{r\}$$

$$\{u_2\} = \{u_1\} + \{\delta u\}$$

$$\text{Print } \{u_2\}$$

```
BEGIN     $
SØLVE     KLL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
SØLVE     KLL,R / DU / C,N,1 $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

Remarks:

1. $[K_{\ell\ell}]$ is assumed symmetric.

2. In the example above, KLL will be decomposed twice. A more efficient DMAP sequence, which requires only a single decomposition for this problem, is given below.

```
BEGIN     $
DECØMP    KLL / LLL,ULL $
FBS       LLL,ULL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
FBS       LLL,ULL,R / DU $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

5.4.3 DMAP Example to Use the Structure Plotter to Generate Undeformed Plots of the Structural Model

```
BEGIN      $
GP1        GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / V,N,NØCSTM / V,N,NØGPDT $
SAVE       LUSET $
GP2        GEØM2,EQEXIN / ECT $
PLTSET     PCDB,EQEXIN,ECT / PLTSETX,PLTPAR,GPSETS,ELSETS / V,N,NSIL / V,N,NPSET $
SAVE       NPSET,NSIL $
PRTMSG     PLTSETX // $
PARAM      // C,N,NØP / V,N,PLTFLG=1 $
PARAM      // C,N,NØP / V,N,PFILE=0 $
CØND       P1,NPSET $
PLØT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,, / PLØTX1 / V,N,NSIL / V,N,LUSET /
           V,N,NPSET / V,N,PLTFLG / V,N,PFILE $
SAVE       NPSET,PLTFLG,PFILE $
PRTMSG     PLØTX1 // $
LABEL      P1 $
PRTPARM    // C,N,0 $
END        $
```

Remarks:

1. GEØM1, GEØM2, PCDB and CASECC are generated by the Input File Processor.

2. PRTPARM is used to print all current variable parameter values.

3. This DMAP sequence contains several structurally oriented modules. This sequence of DMAP instructions is essentially identical with the section of each rigid format associated with the operation of the Structure Plot Request Packet of the Case Control Deck (contained in data block PCDB).

5.4.4 Example of DMAP to Print Eigenvectors Associated with any of the Modal Formulation Rigid Formats

```
BEGIN    $
ØFP      LAMA,ØEIGS,,,, // $
SDR1     USET,,PHIA,,,GØ,GM,,KFS,, / PHIG,,QG / C,N,1 / C,N,REIG $
SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,EST, / , ØQG1,ØPHIG,ØES1,ØEF1, /
         C,N,REIG $
ØFP      ØPHIG,ØQG1,ØEF1,ØES1,, // $
END      $
```

Remarks:

1. A restart from a successfully executed modal formulation is assumed.

2. This DMAP sequence contains several structurally oriented modules.

5.4.5 Example of DMAP Using a User-written Module

As an example of how a user might perform matrix operations of his own design, the following DMAP is provided. Functional modules MØDA, MØDB, and MØDC are assumed to be written by the user and added to the NASTRAN system, replacing dummy modules with the same names. A brief explanation of a problem for which this DMAP is applicable is given.

```
 1   BEGIN     $
 2   PARAM     // C,N,NØP / V,N,TRUE=-1 $
 3   PARAM     // C,N,NØP / V,N,FALSE=+1 $
 4   MØDA      / X,Y,DB,A / V,N,BETA=0.0 / V,N,SIGMA=1.0 / V,N,FW=0.0 / V,N,SW=0.0 /
               V,N,ETAINF=5.0 / V,N,M=100 / C,N,0 / C,N,0 / C,N,0 / V,N,ICØNV=0 /
               V,N,ZCØNV=1.0E-4 / V,N,ITMAX=10 / C,N,0 $
 5   SAVE      BETA,SIGMA,FW,SW,ETAINF,M,ICØNV,ZCØNV,ITMAX $
 6   LABEL     TØP $
 7   FILE      A=SAVE / DB=SAVE $
 8   SØLVE     A,DB / DY / C,N,0 / C,N,1 / C,N,1 / C,N,1 $
 9   EQUIV     X,XX / FALSE / Y,YY / FALSE $
10   MØDB      X,Y,DY / XX,YY,DBB,AA / V,N,BETA / V,N,SIGMA / V,N,FW / V,N,SW / V,N,M /
               C,N,0 / V,N,ICØNV / V,N,ZCØNV / C,N,0 / V,N,DØNE=1 / V,N,DIVERGED=1 $
11   SAVE      DØNE,DIVERGED $
12   CØND      QUIT,DIVERGED $
13   CØND      ØUT,DØNE $
14   EQUIV     XX,X / TRUE / YY,Y / TRUE / DBB,DB / TRUE / AA,A / TRUE $
15   CØND      QUIT,ITMAX $
16   REPT      TØP,1000 $
17   PRTPARM   // C,N,-1 / C,N,DMAP $
18   EXIT      $
19   LABEL     ØUT $
20   MØDC      X,Y // $
21   EXIT      $
22   LABEL     QUIT $
23   PRTPARM   // C,N,-2 / C,N,DMAP $
24   EXIT      $
25   END       $
```

The above DMAP sequence is designed to solve an iteration problem where {x} is the set of independent variable values on which the discretized solution {y(x)} is defined. Let the discrete values of {y(x)} measured at {x} be called {y}. An iteration sequence

$$\{y\}^{i+1} = \{y\}^{i} + [A(\{y\}^{i},\{x\})]^{-1}\{\delta b(\{y\}^{i},\{x\})\}$$

is to be performed where [A] and $\{\delta b\}$ are computable functions of $\{y\}$ and $\{x\}$. A convergence-divergence criterion is assumed known. It is also assumed that the independent variable distribution $\{x\}$ may be modified as the solution proceeds. A brief description of the significant DMAP instructions is given below:

4 Initialization of all parameters and output data blocks. This module is assumed to be written by the user.

7 Prevents file allocator from dropping A and DB.

8 Compute $\{\delta y\} = [A]^{-1}\{\delta b\}$

9 Break equivalences.

10 Iterate to obtain new $\{x\}$, $\{y\}$, $\{\delta b\}$, [A]; test convergence and set parameters DØNE and DIVERGED. This module is assumed to be written by the user.

14 The new $\{x\}$, $\{y\}$, $\{\delta b\}$, [A] are established as current by replacing the old values.

20 Prints out the converged solutions $\{x\}$ and $\{y\}$. This module is assumed to be written by the user.

5.4.6 DMAP ALTER Package for Using a User-Written Auxiliary Input File Processor

```
ALTER        1
INPUT        GEØM1,,,, / G1,,,G4, / C,N,3 $
PARAM        // C,N,NØP / V,N,TRUE=-1 $
EQUIV        G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
CØND         LBLXXX,TRUE $
TABPT        G1,G4,,, // $
LABEL        LBLXXX $
ENDALTER
```

Remarks:

1. This is an ALTER package that could be used by any Rigid Format.

2. The last three instructions are needed to avoid violating the Equivalence rule that a primary data block name must be referenced in a subsequent functional module. A way to avoid using these three instructions is to move the PARAM ahead of INPUT, in which case the EQUIV immediately follows the module in which the primary data blocks are output. In this case the ALTER package becomes

```
ALTER        1
PARAM        // C,N,NØP / V,N,TRUE=-1 $
INPUT        GEØM1,,,, / G1,,,G4, / C,N,3 $
EQUIV        G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
ENDALTER
```

3. It is assumed that a user-written module INPUT exists which reads data block GEØM1 (created by the Input File Processor of the NASTRAN Preface) and creates data blocks G1 and G4. It is then desired to use G1 and G4 in place of GEØM1 and GEØM4, the data blocks normally created by the NASTRAN Preface.

4. ALTER is described in Section 2.2.

5.4.7 DMAP to Perform Real Eigenvalue Analysis Using Direct Input Matrices

```
BEGIN      $
READ       KTEST,MTEST,,,DYNAMICS,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NE $
ØFP        LAMA,ØEIGS,,,, // $
MATPRN     PHIA,,,, // $
END        $
```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

```
.  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
DMI     KTEST   0       6       1       2               4       4
DMI     KTEST   1       1       200.0   -100.0
DMI     KTEST   2       1       -100.0  200.0   -100.0
DMI     KTEST   3       2       -100.0  200.0   -100.0
DMI     KTEST   4       3       -100.0  200.0
DMI     MTEST   0       6       1       2               4       4
DMI     MTEST   1       1       1.0
DMI     MTEST   2       2       1.0
DMI     MTEST   3       3       1.0
DMI     MTEST   4       4       1.0
EIGR    1       DET     .0      2.5     2       2                       +1
+1      MAX
```

2. Data blocks DYNAMICS and CASECC are generated by the NASTRAN Preface (Input File Processor) and contain the eigenvalue extraction data from the EIGR card and the eigenvalue method selection data extracted from the METHØD card in the Case Control Deck.

3. Data blocks KTEST and MTEST are generated by the NASTRAN Preface (Input File Processor) from the DMI bulk data cards.

4. Data block MI is the modal mass matrix, which is not used in this DMAP subsequent to READ, but which must appear as an output in READ. Parameter NE is an output parameter whose value is the number of eigenvalues extracted. If none are found NE will be set to -1.

Alternate DMAP to perform real eigenvalue analysis using Direct Input Matrices where the degrees of freedom are associated with grid points.

EXAMPLES

```
BEGIN     $
GP1       GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / C,N,0 / C,N,0 $
SAVE      LUSET $
GP4       CASECC,,EQEXIN,SIL,GPDT / ,,USET, / V,N,LUSET / C,N,0 / C,N,0 / C,N,0 / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 $
DPD       DYNAMICS,GPL,SIL,USET / GPLD,SILD,USETD,,,,,,,EED,EQDYN / V,N,LUSET / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / V,N,NØEED / C,N,0 / C,N,0 $
SAVE      NØEED $
CØND      E1,NØEED $
READ      KTEST,MTEST,,,EED,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NEIGV $
SAVE      NEIGV $
ØFP       LAMA,ØEIGS,,,, // $
CØND      FINIS,NEIGV $
SDR1      USET,,PHIA,,,,,,,, / PHIG,, / C,N,1 / C,N,REIG $
SDR2      CASECC,,,,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,, / ,,ØPHIG,,, / C,N,REIG $
ØFP       ØPHIG,,,,, // $
JUMP      FINIS $
LABEL     E1 $
PRTPARM   // C,N,-2 / C,N,MØDES $
LABEL     FINIS $
END       $
```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

```
.  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
DMI     KTEST   0       6       1       2               4       4
DMI     KTEST   1       1       200.0   -100.0
DMI     KTEST   2       1       -100.0  200.0   -100.0
DMI     KTEST   3       2       -100.0  200.0   -100.0
DMI     KTEST   4       3       -100.0  200.0
DMI     MTEST   0       6       1       2               4       4
DMI     MTEST   1       1       1.0
DMI     MTEST   2       2       1.0
DMI     MTEST   3       3       1.0
DMI     MTEST   4       4       1.0
EIGR    1       DET     .0      2.5     2       2                       +1
+1      MAX
SPØINT  1       THRU    4
```

2. Data block EED is generated by DPD, which copies the EIGR or EIGB cards from data block DYNAMICS. The actual card used is selected in case control by METHØD = SID.

3. Each degree-of-freedom defined by the DMI matrices must be associated with some grid or scalar point in this version. In the example above, this is done by defining four scalar points.

4. The EIGR card selected in the Case Control Deck will be used as explained in Note 2.

5. The use of module MTRXIN and DMIG bulk data cards will allow the user to input matrices via grid point identification numbers.

5.4.8 DMAP Example to Print and Plot a Topological Picture of Two Matrices

```
 1.  BEGIN     $
 2.  SEEMAT    KGG,KLL,,, // $
 3.  SEEMAT    KGG,KLL,,, // C,N,PLØT / V,N,P=0 / C,N / C,N,SC / C,N,4020 / C,N,X / C,N,0 $
 4.  SAVE      P $
 5.  PRTPARM   // C,N,0 / C,N,P $
 6.  PARAM     // C,N,MPY / V,N,P / C,N,0 / C,N,1 $
 7.  SEEMAT    KGG,KLL,,, // C,N,PLØT / V,N,P / C,N / C,N,EAI / C,N,3500 / C,N,X / C,N,30 $
 8.  SAVE      P $
 9.  PRTPARM   // C,N,0 / C,N,P $
10.  END       $
```

Notes:

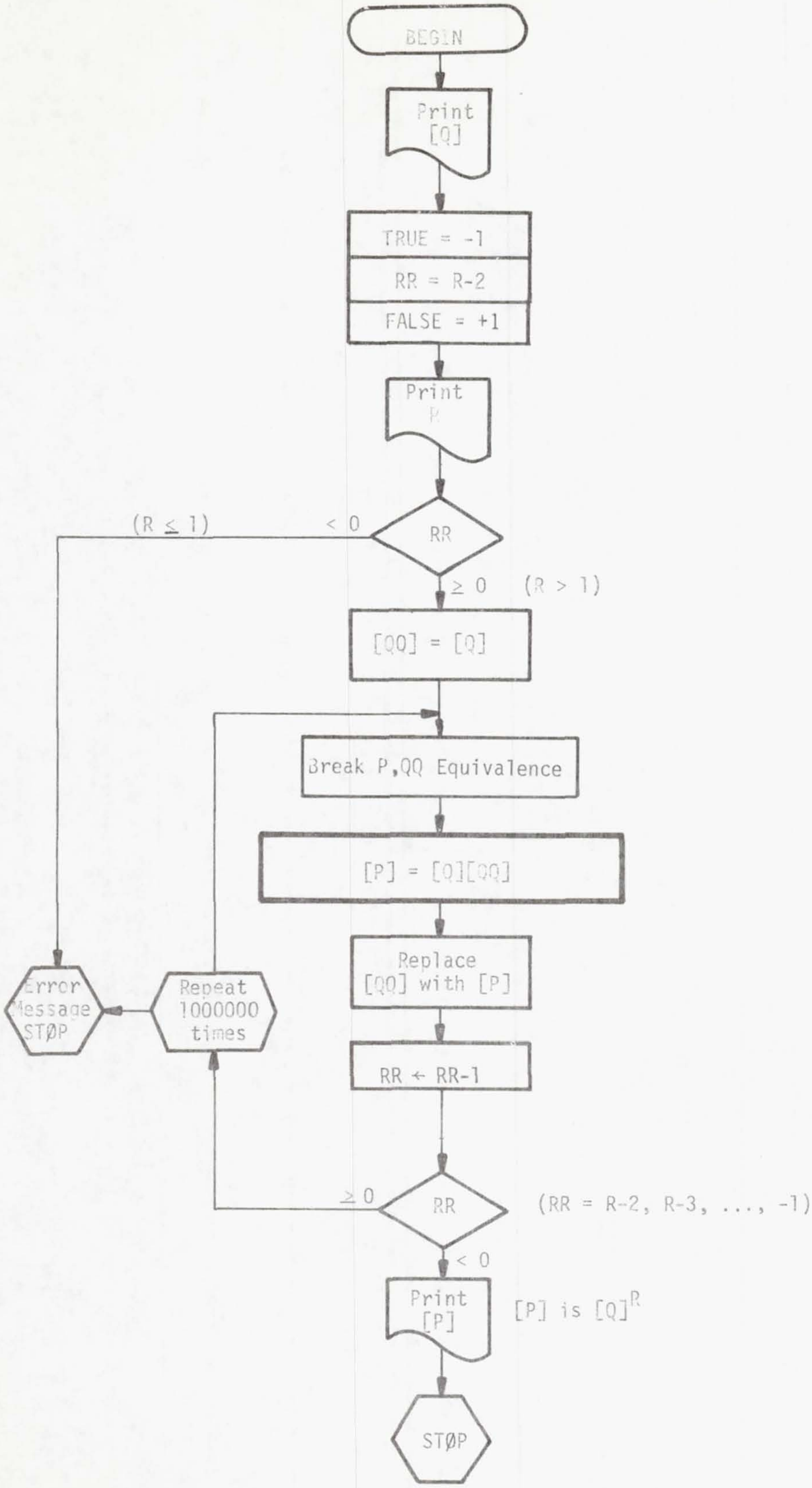
1. Instruction number 2 causes the picture to be generated on the printer.
2. Instruction number 3 causes the picture to be generated on the SC 4020 plotter.
3. The parameter P is initialized to zero by instruction number 3. The form V,N,P would also have accomplished the same thing since the MPL default value is zero.
4. Instruction number 5 prints the current value of parameter P. Since P was initially set to zero and instruction number 3 is the first instruction executed which has P as an input, then P will have a zero value on input to instruction number 3. P is incremented by one (1) for every frame generated on the SC 4020 plotter. Since the value of the output parameter P was saved in the immediately following SAVE instruction, the value printed by instruction number 5 will be the number of frames generated by the execution of instruction number 3.
5. Instruction number 6 causes the value of P to be set to zero (0), the product of zero (0) and one (1). Since PARAM is the only module which does its own SAVE, no succeeding SAVE instruction is necessary. This illustrates a commonly used technique for setting parameter values in DMAP programs.
6. Instructions 7, 8 and 9 essentially repeat instructions 3, 4 and 5 using the EAI 3500 table plotter in place of the SC 4020 plotter.
7. The END instruction, which is required, also acts as an EXIT instruction.
8. NASTRAN tapes PLT1 and PLT2 must both be set up in order to execute this DMAP successfully.
9. Matrix data blocks KGG and KLL are assumed to exist on the PØØL file. This will be the case if either DMI input is used or if a restart is being made from a run in which KGG and KLL were generated and checkpointed.

5.4.9 DMAP Example to Compute the r-th Power of a Matrix [Q]

```
BEGIN      $
MATPRN     Q,,,, // $
PARAM      // C,N,NØP / V,N,TRUE=-1 $
PARAM      // C,N,SUB / V,N,RR / V,Y,R=-1 / C,N,2 $
PARAM      // C,N,NØP / V,N,FALSE=+1 $
CØND       ERRØR1,RR $
ADD        Q, / QQ $
LABEL      DØIT $
EQUIV      QQ,P / FALSE $
MPYAD      Q,QQ, / P / C,N,0 $
EQUIV      P,QQ / TRUE $
PARAM      // C,N,SUB / V,N,RR / V,N,RR / C,N,1 $
CØND       STØP,RR $
REPT       DØIT,1000000 $
JUMP       ERRØR2 $
LABEL      STØP $
MATPRN     P,,,, // $
EXIT       $
LABEL      ERRØR1 $
PRTPARM    // C,N,-1 / C,N,DMAP $
EXIT       $
LABEL      ERRØR2 $
PRTPARM    // C,N,-2 / C,N,DMAP $
EXIT       $
END        $
```

Notes:

1. The matrix [Q] is assumed input via DMI bulk data cards.
2. The parameter R is assumed input on a PARAM bulk data card.
3. A logical flow diagram for this DMAP is shown in the following sketch.


BEGIN
Print [Q]
TRUE = -1
RR = R-2
FALSE = +1
Print P
RR
(R ≤ 1)
< 0
≥ 0
(R > 1)
[QQ] = [Q]
Break P,QQ Equivalence
[P] = [Q][QQ]
Replace [QQ] with [P]
RR ← RR-1
Error Message STØP
Repeat 1000000 times
RR
≥ 0
(RR = R-2, R-3, ..., -1)
< 0
Print [P]
[P] is [Q]^R
STØP

5.4.10 Usage of UPARTN, VEC, and PARTN

In Rigid Format No. 7 (Series L), the functional module SMP1 performs the following matrix operations:

$$[K_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

$$[G_o] = -[K_{oo}]^{-1} \; [K_{oa}]$$

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}]^T [G_o]$$

$$[M_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

$$[A] = [M_{oo}] \; [G_o] + [M_{oa}]$$

$$[B] = [M_{oa}]^T \; [G_o] + [\bar{M}_{aa}]$$

$$[M_{aa}] = [G_o]' \; [A] + \lfloor B \rfloor$$

$$[K^4_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

$$[A] = [K^4_{oo}] \; [G_o] + [K^4_{oa}]$$

$$[B] = [K^4_{oa}]^T \; [G_o] + [\bar{K}^4_{aa}]$$

$$[K^4_{aa}] = [G_o]^T \; [A] + [B]$$

$$[B_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{B}_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

$$[A] = [B_{oo}] \; [G_o] + [B_{oa}]$$

$$[B] = [B_{oa}]^T \; [G_o] + [\bar{B}_{aa}]$$

$$[B_{aa}] = [G_o]^T \; [A] + [B]$$

This is far too many time-consuming matrix operations to perform within a single module when both the a-set and o-set are large. (Remember, checkpoint only occurs after the module has done all its work.) One way to break the Rigid Format series L SMP1 into parts is to use an ALTER packet similar to the ALTER Packet which follows for Rigid Format No. 7 (Series L). This would yield a DMAP sequence similar to Rigid Format series M.

```
ALTER 74, 75 $ RIGID FØRMAT SERIES L
SMP1 USET,KFF,,,/GØ,KAA,KØØB,LØØ,UØØ,,,,, $
CHKPNT KAA,GØ $
SMP2 USET,GØ,MFF/MAA $
CHKPNT MAA $
SMP2 USET,GØ,BFF/BAA $
CHKPNT BAA $
SMP2 USET,GØ,K4FF/K4AA $
CHKPNT K4AA $
ENDALTER
```

Unfortunately, most of the time is now spent in SMP2. In order to subdivide the matrix operations further, the partitions of the matrices $[K_{ff}]$ etc. must be obtained. There are two new modules in Level 15 which can be used to do this. The first is UPARTN which forms the symmetric partitions of a symmetric matrix.

EXAMPLES

SMP1 and SMP2 using UPARTN in Level 15 for Rigid Format No. 7 (Series M)

```
ALTER     74,84 $   ALTER TØ SERIES M
$
UPARTN    USET,KFF / KØØ, ,KØA,KAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    KØØ,KØA,KAAB $
SØLVE     KØØ,KØA / GØ / C,N,1 / C,N,-1 $
CHKPNT    GØ $
MPYAD     KØA,GØ,KAAB / KAA / C,N,1 $
CHKPNT    KAA $
$
UPARTN    USET,MFF / MØØ, ,MØA,MAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    MØØ,MØA,MAAB $
MPYAD     MØØ,GØ,MØA / MAATEMP1 / C,N,0 $
CHKPNT    MAATEMP1 $
MPYAD     MØA,GØ,MAAB / MAATEMP2 / C,N,1 $
CHKPNT    MAATEMP2 $
MPYAD     GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 $
CHKPNT    MAA $
$
UPARTN    USET,K4FF / K4ØØ, ,K4ØA,K4AAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    K4ØØ,K4ØA,K4AAB $
MPYAD     K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 $
CHKPNT    K4AATMP1 $
MPYAD     K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 $
CHKPNT    K4AATMP2 $
MPYAD     GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 $
CHKPNT    K4AA $
$
UPARTN    USET,BFF / BØØ, ,BØA,BAAB / C,N,F / C,N,Ø / C,N,A $
CHKPNT    BØØ,BØA,BAAB $
MPYAD     BØØ,GØ,BØA / BAATEMP1 / C,N,0 $
CHKPNT    BAATEMP1 $
```

```
MPYAD     BØA,GØ,BAAB / BAATEMP2 / C,N,1 $
CHKPNT    BAATEMP2 $
MPYAD     GØ,BAATEMP1,BAATEMP2 / BAA / C,N,1 $
CHKPNT    BAA $
$
ENDALTER
```

EXAMPLES

In order to subdivide the matrix operations further, the partitioning information contained in USET must be made available to PARTN and MERGE so that the various matrix partitions can be formed external to SMP2 and manipulated with matrix operation modules such as MPYAD. In Level 15, the utility module VEC has been written to accomplish this task. The ALTER Packet on the following page shows the replacement of Structural Matrix Partitioning in Rigid Format No. 7 (Series M) using this utility module.

SMP1 and SMP2 using VEC and PARTN in Level 15 for Rigid Format No. 7 (Series M)

```
ALTER     74,84
$
VEC       USET / V / C,N,F / C,N,Ø / C,N,A $
CHKPNT    V $
$
PARTN     KFF,V, / KØØ, ,KØA,KAAB $
CHKPNT    KØØ,KØA,KAAB $
DECØMP    KØØ / LØØ,UØØ / C,N,1 / C,N,0 / V,N,MIND / V,N,DET / V,N,NDET / V,N,SING $
SAVE      MIND,DET,NDET,SING $
CØND      LSING,SING $
CHKPNT    LØØ,UØØ $
FBS       LØØ,UØØ,KØA / GØ / C,N,1 / C,N,-1 $
CHKPNT    GØ $
MPYAD     KØA,GØ,KAAB / KAA / C,N,1 $
CHKPNT    KAA $
$
PARTN     MFF,V, / MØØ, ,MØA,MAAB $
CHKPNT    MØØ,MØA,MAAB $
MPYAD     MØØ,GØ,MØA / MAATEMP1 / C,N,0 $
CHKPNT    MAATEMP1 $
MPYAD     MØA,GØ,MAAB / MAATEMP2 / C,N,1 $
CHKPNT    MAATEMP2 $
MPYAD     GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 $
CHKPNT    MAA $
$
PARTN     K4FF,V, / K4ØØ, ,K4ØA,K4AAB $
CHKPNT    K4ØØ,K4ØA,K4AAB $
MPYAD     K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 $
CHKPNT    K4AATMP1 $
MPYAD     K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 $
CHKPNT    K4AATMP2 $
```

```
MPYAD     GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 $
$
PARTN     BFF,V, / BØØ, ,BØA,BAAB $
CHKPNT    BØØ,BØA,BAAB $
MPYAD     BØØ,GØ,BØA / BAATEMP1 / C,N,0 $
CHKPNT    BAATEMP1 $
MPYAD     BØA,GØ,BAAB / BAATEMP2 / C,N,1 $
CHKPNT    BAATEMP2 $
MPYAD     GØ,BAATEMP1,BAATEMP2 / BAA / C,N,1 $
CHKPNT    BAA $
$
ALTER   163  $  ADD ERRØR TRAP FØR SINGULAR KØØ MATRIX  IN R.F. 7 (SERIES M)
$
LABEL     LSING $
PRTPARM   // C,N,0 / C,N,SING $
PRTPARM   // C,N,-1 / C,N,DMAP $
EXIT      $
$
ENDALTER
```

5.4.11 DMAP Example

Let A, B and C be matrices whose values are to be defined at execution time. Let β be a real constant whose value is to be defined at execution time. Let α be an integer constant whose value (defined at execution time) determines the operations to be performed to compute matrix X as follows:

$$[X] = \begin{cases} [A][B] + [C] & , \alpha < 0 \\ \left[\beta[A] + [B]\right]^T & , \alpha = 0 \\ [A]^2[C]^{-1} & , \alpha > 0 \end{cases}$$

Write a DMAP to accomplish the above, assuming A, B and C will be defined by DMI bulk data cards and that α and β will be defined on PARAM bulk data cards. Print the inputs and outputs using the DMAP Utility Functional Modules MATPRN and PRTPARM. Use the DMAP Utility Module SEEMAT to print a topology display of [A] and [X].

A solution to this problem is given on the following page along with data for an actual example.

```
ID A,B
TIME 5
APP DMAP
BEGIN $
JUMP START $
PARAM // C,N,NØP / V,N,TRUE=-1 $  SET TRUE TØ -1 (=.TRUE.)
LABEL START $
MATPRN A,B,C,, // $
CØND ØNE,ALPHA $
PARAM // C,N,NØT / V,N,CHØØSE / V,Y,ALPHA $
CØND THREE,CHØØSE $
JUMP TWØ $
$
LABEL ØNE $                                              ALPHA .LT. 0
MPYAD A,B,C / X / C,N,0 $
JUMP FINIS $
$
LABEL TWØ $                                              ALPHA .EQ. 0
ADD A,B / Y / C,Y,BETA=(0.0,0.0) $
TRNSP Y / X2 $
EQUIV X2,X / TRUE $
JUMP FINIS $
$
LABEL THREE $                                            ALPHA .GT. 0
SØLVE C, / Z $
MPYAD A,Z, / W / C,N,0 $
MPYAD A,W, / X3 / C,N,0 $
EQUIV X3,X / TRUE $
$
LABEL FINIS $
MATPRN X,,,, // $
SEEMAT A,X,,, // C,N,PRINT $
PRTPARM // C,N,0 $
END $
CEND
TITLE = TEST MPYAD
BEGIN BULK
DMI       A         0         6         1         2                   2         2
DMI       A         1         1         1.01
DMI       A         2         2         1.01
DMI       B         0         6         1         2                   2         2
DMI       B         1         1         1.01
DMI       B         2         2         1.01
DMI       C         0         6         1         2                   2         2
DMI       C         1         1         1.01
DMI       C         2         2         1.01
PARAM     ALPHA     -1
PARAM     BETA      1.0       .0
ENDDATA
```

DIAGNOSTIC MESSAGES

6.1 RIGID FORMAT DIAGNOSTIC MESSAGES

A number of fatal errors are detected by DMAP statements in the various rigid formats. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or that can be more effectively detected by DMAP statements in the rigid format. The detection of such an error causes a transfer to a LABEL instruction near the end of the rigid format. The text of the message is output and the execution is terminated. These messages will always appear at the end of the NASTRAN output.

The texts of the rigid format error messages are given in the following sections for each of the rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.1 Rigid Format Error Messages for Static Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.2 Rigid Format Error Messages for Static Analysis with Inertia Relief

NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS ARE REQUIRED.

A statically determinate set of supports must be specified on a SUPØRT card in order to determine the rigid body characteristics of the structural model.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.3 Rigid Format Error Messages for Normal Mode Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.4 Rigid Format Error Messages for Static Analysis with Differential Stiffness

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Static Analysis with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 scale factors for differential stiffness calculations. This number may be increased by altering the REPT instruction following SDR1.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NO. 6 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring multiple differential load factor was run on subset (1 or 3) which does not support them. The problem should be restarted on subset 0.

6.1.5 Rigid Format Error Messages for Buckling Analysis

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Buckling Analysis. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGB card and METHØD must select an EIGB set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUES FØUND.

No buckling modes exist in the range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.6 Rigid Format Error Messages for Piecewise Linear Analysis.

NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

A piecewise linear problem has not been formulated because none of the elements have a stress dependent modulus of elasticity defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 load increments. This number may be increased by altering the REPT instruction preceding SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

The stiffness matrix is singular due either to one or more grid point singularities or element material plasticity.

6.1.7 Rigid Format Error Messages for Direct Complex Eigenvalue Analysis.

NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGC card and CMETHØD must select an EIGC set in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined an a Property card, or the density was not defined on a Material card.

6.1.8 Rigid Format Error Messages for Direct Frequency and Random Response.

NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the Case Control Deck.

NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.9 Rigid Format Error Message for Direct Transient Response

NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number may be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.10 Rigid Format Error Messages for Modal Complex Eigenvalue Analysis.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

6.1.11 Rigid Format Error Messages for Modal Frequency and Random Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number can be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the the Case Control Deck.

NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

6.1.12 Rigid Format Error Messages for Modal Transient Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

DIAGNOSTIC MESSAGES

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number can be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

6.2 NASTRAN SYSTEM AND USER MESSAGES

NASTRAN system and user messages are identified by number. Message numbers have been assigned in groups as follows:

1 - 1000	Preface Messages
1001 - 2000	Executive Module Messages
2001 -	Functional Module Messages

These messages have the following format:

$$*** \left\{ \begin{array}{l} \text{SYSTEM} \\ \text{USER} \end{array} \right\} \left\{ \begin{array}{l} \text{FATAL} \\ \text{WARNING} \\ \text{INFØRMATIØN} \end{array} \right\} \text{MESSAGE id, text.}$$

where "id" is a unique message identification number and "text" is the message as indicated in capital letters for each of the diagnostic messages. A series of asterisks (****) in the text indicates information that will be filled in for a specific use of the message, such as, the number of a grid point or the name of a bulk data card. Many of the messages are followed by additional explanatory material, including suggestions for remedial action.

The system and user messages described in this section pertain only to those messages generated by NASTRAN. Although these messages can appear at various places in the output stream, they should be easily identified by their format. The various computer operating systems also produce diagnostic messages that can appear at various places in the output stream. The format of these messages will vary with the operating system. Reference should be made to the operating system manuals for interpretation of the messages that are not generated by NASTRAN.

System messages refer to diagnostics that are associated with program errors. In general such errors cannot be corrected by the user. Reference should be made to the Programmer's Manual and assistance secured from the programming staff. User messages refer to errors that are usually associated with the preparation of the NASTRAN Data Deck. Corrective action is indicated in the message text or the explanatory information following the text. In some cases reference may have to be made to other sections of the User's Manual for proper card formats or for clarification of procedures.

Fatal messages cause the termination of the execution following the printing of the message text. These messages will always appear at the end of the NASTRAN output. Warning and information

messages will appear at various places in the output stream. Such messages only convey warnings or information to the user. Consequently, the execution continues in a normal manner following the printing of the message text.

As an example, consider message number 2025, which will appear in the printed output as follows:

*** USER FATAL MESSAGE 2025, UNDEFINED CØØRDINATE SYSTEM 102.

The three leading asterisks (***) are always present in user and system diagnostic messages. The word USER indicates that this is a user message rather than a system message. The word FATAL indicates that this is a fatal message rather than a warning or information message. The number 2025 is the identification number for this message. The text of the message follows the comma (,). The number 102 replaces the asterisks (****) in the general message text, and indicates that 102 is the identification number of the undefined coordinate system.

6.2.1 Preface Messages

01 *** USER WARNING MESSAGE 1, ASSUMED FIRST INPUT FILE IS NULL.
User has specified N input data blocks when there should be N+1.

02 *** USER WARNING MESSAGE 2, PARAMETER NAMED ******** IS DUPLICATED.
No harm done. Parameter is saved just once.

03 *** USER FATAL MESSAGE 3, FØRMAT ERRØR IN PARAMETER NØ.***.
Double delimiter appears in parameter section of previous DMAP instruction.

04 *** SYSTEM FATAL MESSAGE 4, MPL PARAMETER ERRØR, MØDULE NAME = ******** PARAMETER NØ.***.
MPL entry for module is incorrect. See block data program XMPLBD.

05 *** USER FATAL MESSAGE 5, PARAMETER INPUT DATA ERRØR ILLEGAL VALUE FØR PARAMETER NAMED ********.
Type of parameter on PARAM card is inconsistent with type of parameter by same name in above DMAP instruction.

06 *** USER FATAL MESSAGE 6, ILLEGAL VALUE FØR PARAMETER NØ.***.
The type of parameter in DMAP instruction does not correspond to type requested in DMD or MFD section of Programmer's Manual.

07 *** USER FATAL MESSAGE 7, PARAMETER NØ.*** NEEDS PARAMETER NAME.
Parameter is not in correct format.

08 *** USER FATAL MESSAGE 8, BULK DATA PARAM CARD ERRØR. MUST NØT DEFINE PARAMETER NAMED ********.

The "N" in V,N,******** means user cannot set the value of the parameter with name ******** on a PARAM card.

09 *** USER FATAL MESSAGE 9, VALUE NEEDED FØR PARAMETER NØ. ***.

Constant needs value in DMAP instruction or on PARAM card.

10 *** USER FATAL MESSAGE 10, ILLEGAL INPUT SECTIØN FØRMAT.

11 *** USER FATAL MESSAGE 11, ILLEGAL ØUTPUT SECTIØN FØRMAT.

12 *** USER FATAL MESSAGE 12, ILLEGAL CHARACTER IN DMAP INSTRUCTIØN NAME.

Name must be 8 or less alpha-numeric characters, the first character being alpha.

13 *** USER FATAL MESSAGE 13, DMAP INSTRUCTIØN NØT IN MØDULE LIBRARY.

14 *** SYSTEM FATAL MESSAGE 14, ARRAY NAMED ******** ØVERFLØWED.

See XGPI module description in MFD section of Programmer's Manual.

15 *** USER FATAL MESSAGE 15, INCØNSISTENT LENGTH USED FØR PARAMETER NAMED ********.

This parameter was used in a previous DMAP instruction which gave it a different type. See Section 5.2.1 of the User's Manual.

16 *** USER FATAL MESSAGE 16, ILLEGAL FØRMAT.

17 *** USER FATAL MESSAGE 17, UNIDENTIFIED NASTRAN CARD KEYWØRD ********. ACCEPTABLE KEYWØRDS FØLLØW ---

18 *** USER FATAL MESSAGE 18, TØØ MANY PARAMETERS IN DMAP PARAMETER LIST.

Incorrect calling sequence for DMAP instruction.

19 *** USER FATAL MESSAGE 19, LABEL NAMED ******** IS MULTIPLY DEFINED.

LABEL named appears in more than one place in DMAP program.

20 *** USER FATAL MESSAGE 20, ILLEGAL CHARACTERS IN PARAMETER NØ. ***.

Name must be 8 or less alpha-numeric characters, the first character being alpha.

21 *** USER FATAL MESSAGE 21, PARAMETER NAMED ******** IS NØT IN PRECEDING DMAP INSTRUCTIØN PARAMETER LIST.

Parameters in SAVE instruction must appear in immediately preceding DMAP instruction.

22 *** USER FATAL MESSAGE 22, DATA BLØCK NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

23 *** USER FATAL MESSAGE 23, DATA BLØCK NAMED ******** IS NØT REFERENCED IN SUBSEQUENT FUNCTIØNAL MØDULE.

See Section 5.2 of the User's Manual. Error can be suppressed by adding the following :

```
PARAM   //C,N,NØP/V,N,TRUE=-1 $
CØND    LABELXXX,TRUE $
TABPT   ********,,,,// $
LABEL   LABELXXX $
```

24 *** SYSTEM FATAL MESSAGE 24, CANNØT FIND FILE NAMED ******** ØN DATA PØØL TAPE.

Contents of /XDPL/ does not match contents of Pool Tape.

25 *** USER FATAL MESSAGE 25, PARAMETER NAMED ******** NØT DEFINED.

Parameter is referenced in nonfunctional module, but is nowhere defined.

26 *** USER FATAL MESSAGE 26, LABEL NAMED ******** NØT DEFINED.

LABEL name does not appear in LABEL instruction.

27 *** USER WARNING MESSAGE 27, LABEL NAMED ******** NØT REFERENCED.

LABEL name appears only in a LABEL instruction.

28 *** SYSTEM FATAL MESSAGE 28, UNEXPECTED END ØF TAPE ØN NEW PRØBLEM TAPE.

Either you truly encountered an EØT or file linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.

29 *** SYSTEM FATAL MESSAGE 29, UNEXPECTED END ØF TAPE ØN ØLD PRØBLEM TAPE.

File linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.

30 *** SYSTEM FATAL MESSAGE 30, UNEXPECTED END ØF TAPE ØN DATA PØØL TAPE.

See Message 28.

31 *** SYSTEM FATAL MESSAGE 31, CØNTRØL FILE ******** INCØMPLETE ØR MISSING ØN NEW PRØBLEM TAPE.

Data block XCSA is not in correct format or it is missing.

32 *** USER FATAL MESSAGE 32, FILE NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

33 *** SYSTEM FATAL MESSAGE 33, NAME (********) IN NEW CØNTRØL FILE DICTIØNARY NØT VALID.

First record of data block XCSA on Problem Tape contains a name which is not recognized by XGPI module.

34 *** SYSTEM FATAL MESSAGE 34, CANNØT TRANSLATE DMAP INSTRUCTIØN NØ.***.

Error in subroutine XSCNDM or XRCARD.

35 *** USER FATAL MESSAGE 35, INCØRRECT ØLD PRØBLEM TAPE MØUNTED. ID ØF TAPE MØUNTED = ********, ********,**/**/** FILE =***. ID ØF TAPE DESIRED = ********,********,**/**/** FILE =***.

Wrong reel mounted for multireel Problem Tape.

36 *** SYSTEM FATAL MESSAGE 36, CANNØT FIND FILE NAMED ******** ØN ØLD PRØBLEM TAPE.

Header record of file on Problem Tape does not match file name in restart dictionary.

37 *** USER WARNING MESSAGE 37, WARNING ØNLY - MAY NØT BE ENØUGH FILES AVAILABLE FØR MØDULE REQUIREMENTS. FILES NEEDED = *** FILES AVAILABLE = ***.

Program will execute if enough data blocks referenced by the module are purged. Purged data blocks are not assigned files.

38 *** SYSTEM FATAL MESSAGE 38, NØT ENØUGH CØRE FØR GPI TABLES

User must break up DMAP program.

39 *** SYSTEM FATAL MESSAGE 39, RIGID FØRMAT DMAP SEQUENCE DØES NØT CØRRESPØND TØ MED TABLE.

The MED Table must have the same number of entries as there are DMAP instructions in DMAP sequence.

40 *** USER FATAL MESSAGE 40, ERRØR IN ALTER DECK - CANNØT FIND END ØF DMAP INSTRUCTIØN.

User should check ALTER part of the Executive Control Deck.

41 *** SYSTEM FATAL MESSAGE 41, TABLES INCØRRECT FØR REGENERATING DATA BLØCK ********.

File Name Table and MED Table used by routine XFLDEF are wrong.

42 *** USER WARNING MESSAGE 42, PARAMETER NAMED ******** ALREADY HAD VALUE ASSIGNED PREVIØUSLY.

Parameter appears in a previous instruction which assigned it a value.

43 *** USER FATAL MESSAGE 43, INCØRRECT FØRMAT FØR NASTRAN CARD.

44 *** USER FATAL MESSAGE 44, UNABLE TØ FIND END DMAP INSTRUCTIØN.

User has altered out the END instruction.

45 *** USER FATAL MESSAGE 45, DATA BLØCK NAMED ******** ALREADY APPEARED AS ØUTPUT ØR WAS USED AS INPUT BEFØRE BEING DEFINED.

See Section 5.2 of the User's Manual.

46 *** USER FATAL MESSAGE 46, INCØRRECT REENTRY PØINT.

The last reentry card in the restart dictionary has a DMAP instruction number greater than the instruction number on the END card of the DMAP program.

47 *** USER FATAL MESSAGE 47, THIS INSTRUCTIØN CANNØT BE FIRST INSTRUCTIØN ØF LØØP.

CHKPNT DMAP instruction must not follow a LABEL instruction which is located at the top of a loop.

48 *** USER WARNING MESSAGE 48, DATA BLØCK ******** IS ALWAYS REGENERATED, THEREFØRE IT WILL NØT BE CHECKPØINTED.

This data block is generated by Input File Processors (IFP) and must not be checkpointed to insure proper restart.

49 *** SYSTEM FATAL MESSAGE 49, MPL TABLE (MØDULE PRØPERTIES LIST) IS INCØRRECT.

Error is in common block /XGP12/.

50 *** SYSTEM FATAL MESSAGE 50, CANNØT FIND JUMP ØSCAR ENTRY NEEDED FØR THIS RESTART.

There must be a dummy JUMP instruction before every LABEL instruction at top of a loop for rigid formats.

51 *** SYSTEM FATAL MESSAGE 51, NØT ENOUGH ØPEN CØRE FØR XGPIBS RØUTINE.

Additional core memory is required.

52 *** SYSTEM FATAL MESSAGE 52, NAMED CØMMØN /XLINK/ IS TØØ SMALL.

There must be one word in LINK table for every entry in MPL.

53 *** USER FATAL MESSAGE 53, INCØRRECT FØRMAT IN ABØVE CARD.

201 *** USER FATAL MESSAGE 201, REQUESTED BULK DATA DECK ********, NØT ØN USER MASTER FILE.

Requested UMF problem identification number not found on currently mounted UMF tape.

202 *** SYSTEM FATAL MESSAGE 202, UMF CØULD NØT BE ØPENED.

User Master File (UMF) not present (destroyed) in FIST.

203 *** SYSTEM FATAL MESSAGE 203, ILLEGAL EØR ØN UMF.

User Master File (UMF) contains no records in requested file.

204 *** USER FATAL MESSAGE 204, CØLD START, NØ BULK DATA.

No data cards were found after the BEGIN BULK card. A blank card will satisfy this rule.

205 *** USER WARNING MESSAGE 205, CØLD START, DELETE CARDS IGNØRED.

Delete (/) cards were present and ignored within the Bulk Data Deck.

206 *** USER FATAL MESSAGE 206, PREVIØUS CØNTINUATIØN MNEMØNIC HAS A DUPLICATE.

Two or more continuation cards were found with column 2-8 identical.

207 *** USER INFØ MESSAGE 207, BULK DATA NØT SØRTED, XSØRT WILL REØRDER DECK.

Bulk Data Deck was not in alpha-numeric sort. Sorting will be performed. Sorting of large deck can be time consuming.

208 *** USER FATAL MESSAGE 208, PREVIØUS CARD IS A DUPLICATE PARENT.

Two or more cards were found with column 74-80 identical and a continuation card is present with that mnemonic (column 2-8).

209 *** USER FATAL MESSAGE 209, PREVIØUS **** CØNTINUATIØN CARDS HAVE NØ PARENTS.

One or more continuation cards were found with a mnemonic (column 2-8) not matching any other card (column 74-80).

210 *** SYSTEM FATAL MESSAGE 210, SCRATCH CØULD NØT BE ØPENED.

One of the required scratch files was not present (destroyed) in FIST.

211 *** SYSTEM FATAL MESSAGE 211, ILLEGAL EØR ØN SCRATCH.

A required scratch file was formatted improperly.

212 *** SYSTEM FATAL MESSAGE 212, ILLEGAL EØF ØN ITAPE4.

Scratch file containing continuations was mispositioned.

213 *** SYSTEM FATAL MESSAGE 213, ILLEGAL EØF ØN ØPTP.

Old Problem Tape contained no bulk data (illegal format).

214 *** SYSTEM FATAL MESSAGE 214, ØPTP CØULD NØT BE ØPENED.

Old Problem Tape (ØPTP) not present (destroyed) in FIST.

215 *** SYSTEM FATAL MESSAGE 215, NPTP CØULD NØT BE ØPENED.

New Problem Tape (NPTP) not present (destroyed) in FIST.

216 *** SYSTEM FATAL MESSAGE 216, ILLEGAL INDEX.

FORTRAN computed-GØ-TØ has received an illogical value.

217 *** SYSTEM FATAL MESSAGE 217, ILLEGAL EØF ØN ITAPE4.

DIAGNOSTIC MESSAGES

300 *** USER FATAL MESSAGE 300, DATA ERRØR IN FIELD UNDERLINED.

A data error as described in the text has been detected by utility routine XRCARD or RCARD.

301 *** USER WARNING MESSAGE 301, BULK DATA CARD ******** CØNTAINS INCØNSISTENT DATA. SØRTED CARD CØUNT = ******

302 *** USER WARNING MESSAGE 302, ØNE ØR MØRE GRID CARDS HAVE DISPLACEMENT CØØRDINATE SYSTEM ID ØF -1.

303 *** SYSTEM FATAL MESSAGE 303, NØ ØPEN CØRE FØR IFP.

Overlay structure must be redefined.

304 *** SYSTEM FATAL MESSAGE 304, IFP NØT READING NPTP **** ****.

The Input File Processor subroutine IFP attempts to locate the bulk data file on the NPTP by searching it forward. The first two words of the file header records are examined for a match with the Hollerith string BULKDATA. If the bulk data is not found by the fifth file, the assumption is made that IFP is either not reading NPTP or that it has been badly written. The header record of fifth file is printed as part of the message.

305 *** SYSTEM FATAL MESSAGE 305, GINØ CANNØT ØPEN FILE ******.
Unexpected nonstandard return from ØPEN.

306 *** SYSTEM FATAL MESSAGE 306, READ LØGIC RECØRD ERRØR.
Short record encountered. Bulk data card images occupy 20 words.

307 *** USER FATAL MESSAGE 307, ILLEGAL NAME FØR BULK DATA CARD ******.
See Section 2.4 of the User's Manual.

308 *** USER FATAL MESSAGE 308, CARD ****** NØT ALLØWED IN ****** APPRØACH.
See Section 2.4 of the User's Manual.

309 *** USER WARNING MESSAGE 309, CARD ****** IMPRØPER IN ******** APPRØACH.
See Section 2.4 of the User's Manual.

310 *** USER FATAL MESSAGE 310, CARD ****** NØT ALLØWED IN SAME DECK AS AXIC CARD.
See Section 2.4 of the User's Manual.

311 *** USER FATAL MESSAGE 311, NØNUNIQUE FIELD 2 ØN BULK DATA CARD ******** ***.
Sorted bulk data card indicated must have a unique integer in field 2.

312 *** USER FATAL MESSAGE 312, TØØ MANY CØNTINUATIØNS FØR BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

313 *** USER FATAL MESSAGE 313, ILLEGAL NUMBER ØF WØRDS ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

314 *** SYSTEM FATAL MESSAGE 314, INVALID CALL FRØM IFP ******.
Code error, machine failure, or cell is being destroyed.

315 *** USER FATAL MESSAGE 315, FØRMAT ERRØR ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

316 *** USER FATAL MESSAGE 316, ILLEGAL DATA ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

317 *** USER FATAL MESSAGE 317, BAD DATA ØR FØRMAT ØR NØN-UNIQUE NAME DTI **** SØRTED CARD CØUNT ****.
See bulk data card description in Section 2.4 of the User's Manual.

318 *** SYSTEM FATAL MESSAGE 318, NØ RØØM IN /XDPL/ FØR DTI ****.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

319 *** SYSTEM FATAL MESSAGE 319, IFP READING EØF ØN NPTP.

Unexpected EØF encountered while attempting to read a card image.

320 *** USER FATAL MESSAGE 320, IFP ERRØR ****** LAST CARD PRØCESSED IS ******.

Code error in IFP or XSØRT.

321 *** USER FATAL MESSAGE 321, NØNUNIQUE PARAM NAME *****.

All names of parameters must be unique.

322 *** SYSTEM FATAL MESSAGE 322, ILLEGAL ENTRY TØ IFSiP.

IFP code error detected in IFS1P, IFS2P, IFS3P, IFS4P, IFS5P.

324 *** USER WARNING MESSAGE 324, BLANK CARD(S) IGNØRED.

Blank bulk data cards are ignored by NASTRAN.

325 *** USER FATAL MESSAGE 325, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMI ******.

See bulk data card description in Section 2.4 of the User's Manual.

326 *** SYSTEM FATAL MESSAGE 326, NØ RØØM IN /XDPL/ FØR DMI ******.

Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

327 *** USER FATAL MESSAGE 327, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMIG ******.

See bulk data card description in Section 2.4 of the User's Manual.

328 *** SYSTEM FATAL MESSAGE 328, ILLEGAL ENTRY TØ IFS3P.

IFP code error.

329 *** USER FATAL MESSAGE 329, ØNLY ØNE (1) AXIC CARD ALLØWED.

See bulk data card description in Section 2.4 of the User's Manual.

330 *** SYSTEM FATAL MESSAGE 330, NØ RØØM IN CØRE FØR PARAM CARDS.

Change overlay or increase core size.

331 *** USER FATAL MESSAGE 331, IMPRØPER PARAM CARD ******.

See bulk data card description in Section 2.4 of the User's Manual.

332 *** USER FATAL MESSAGE 332, AXIC CARD REQUIRED.

The presence of any conical shell data cards requires the presence of an AXIC card.
See the AXIC bulk data card description in Section 2.4 of the User's Manual.

501 *** SYSTEM FATAL MESSAGE 501, MED TABLE INCØRRECT FØR THIS SØLUTIØN.

Input to subroutine XSBSET is incorrect. Look for format error in array SS.

502 *** USER FATAL MESSAGE 502, ILLEGAL SUBSET NUMBER FØR THIS SØLUTIØN.

User specified an incorrect subset number on SØL control card.

503 *** USER FATAL MESSAGE 503, ILLEGAL SØLUTIØN NUMBER.

User specified an incorrect solution number on SØL control card.

504 *** USER FATAL MESSAGE 504, CANNØT CHANGE FRØM SØLUTIØN *** TØ SØLUTIØN ***.

505 *** USER FATAL MESSAGE 505, CONTRØL CARD **** IS ILLEGAL.

Card preceding Message 505 cannot be processed correctly.

506 *** USER FATAL MESSAGE 506, CØNTRØL CARD **** DUPLICATED.

Card preceding Message 506 cannot be input more than once.

507 *** USER FATAL MESSAGE 507, ILLEGAL SPECIFICATIØN ØR FØRMAT ØN PRECEDING CARD.

508 *** USER FATAL MESSAGE 508, PRØBLEM TAPE MUST BE ØN PHYSICAL TAPE FØR CHECKPØINTING.

User requested checkpointing (i.e., CHKPNT YES) therefore Problem Tape must be setup on tape drive.

509 *** USER FATAL MESSAGE 509, WRØNG ØLD PRØBLEM TAPE MØUNTED. ØLD PRØBLEM TAPE ID = ********, ********,**/**/**, REEL NØ. = ***.

The Old Problem Tape identification does not match the identification on the RESTART restart card.

510 *** SYSTEM FATAL MESSAGE 510, CHECKPØINT DICTIØNARY EXCEEDS CØRE SIZE - REMAINING RESTART CARDS IGNØRED.

You have run out of open core. If approach is DMAP try putting restart deck before DMAP sequence. If this does not solve problem, or if approach is not DMAP, then you must decrease size of restart deck.

511 *** SYSTEM FATAL MESSAGE 511, DMAP SEQUENCE EXCEEDS CØRE SIZE - REMAINING DMAP INSTRUCTIØNS IGNØRED.

You have run out of open core. Split the DMAP sequence somewhere prior to where Message 511 was printed out.

512 *** USER FATAL MESSAGE 512, ØLD PRØBLEM TAPE IS MISSING AND IS NEEDED FØR RESTART.

The Problem Tape corresponding to identification on RESTART control card must be setup on the unit assigned to the Old Problem Tape.

513 *** USER FATAL MESSAGE 513, ALTER SEQUENCE NUMBERS ARE ØUT ØF ØRDER.

514 *** USER FATAL MESSAGE 514, ENDALTER CARD IS MISSING.

Alter deck must end with ENDALTER control card.

515 *** USER FATAL MESSAGE 515, END INSTRUCTIØN MISSING IN DMAP SEQUENCE.

DMAP sequence must end with END control card.

516 *** USER FATAL MESSAGE 516, UMF TAPE MUST BE MØUNTED ØN PHYSICAL TAPE DRIVE.

The UMF tape must be setup on the unit assigned to it.

517 *** USER FATAL MESSAGE 517, WRØNG UMF TAPE MØUNTED - TAPE ID = ****.

The tape identification number on the UMF tape does not match the tape identification number on the UMF control card.

518 *** USER FATAL MESSAGE 518, CANNØT USE UMF TAPE FØR RESTART.

519 *** USER FATAL MESSAGE 519, ID CARD MUST PRECEDE ALL ØTHER CØNTRØL CARDS.

520 *** USER FATAL MESSAGE 520, CØNTRØL CARD **** IS MISSING.

The control card mentioned is required for this problem.

521 *** USER FATAL MESSAGE 521, SPECIFY A SØLUTIØN ØR A DMAP SEQUENCE BUT NØT BØTH.

You must either select a DMAP sequence from the library by using the SØL control card or by supplying your own DMAP sequence. Do one or the other but not both.

522 *** USER FATAL MESSAGE 522, NEITHER A SØL CARD NØR A DMAP SEQUENCE WAS INCLUDED.

See Message 521.

523 *** USER FATAL MESSAGE 523, ENDALTER CARD ØUT ØF ØRDER.

ENDALTER control card must be preceded by the ALTER DECK.

524 *** SYSTEM FATAL MESSAGE 524, ALTERNATE RETURN TAKEN WHEN ØPENING FILE ****.

This occurs if file name is not in FIST or the end of tape was reached while writing on the file. The file name should correspond to one of the permanent entries in the FIST.

525 *** SYSTEM FATAL MESSAGE 525, ILLEGAL FØRMAT ENCØUNTERED WHILE READING FILE ****.

File is not in the correct format. Either the wrong tape was mounted or it does not contain what you think it should.

526 *** USER FATAL MESSAGE 526, CHECKPØINT DICTIØNARY ØUT ØF SEQUENCE - REMAINING RESTART CARDS IGNØRED.

The checkpoint dictionary which follows the RESTART control card must be sequenced according to first number on each card.

527 *** USER FATAL MESSAGE 527, DUPLICATE SUBSET NUMBER *****.

601 *** USER FATAL MESSAGE 601, THE KEYWØRD ØN THE ABØVE CARD IS ILLEGAL ØR MISSPELLED. SEE THE FØLLØWING LIST FØR LEGAL KEY WØRDS.

Case control expects each card to begin with a keyword (usually 4 characters in length). Your card does not. User Message 612 will list the legal keywords along with a brief description of function. To remove the error, consult Message 612 or NASTRAN case control card descriptions, User's Manual Section 2.3, and spell your request correctly.

602 *** USER WARNING MESSAGE 602, TWØ ØR MØRE ØF THE ABØVE CARD TYPES DETECTED WHERE ØNLY ØNE IS LEGAL. THE LAST FØUND WILL BE USED.

Remove the card with the duplicate meaning. Note that some cards have alternate forms.

603 *** USER FATAL MESSAGE 603, THE ABØVE CARD DØES NØT END PRØPERLY. CØMMENTS SHØULD BE PRECEDED BY A DØLLAR SIGN.

Case control cards of the form, name = value, should not contain more than one value. Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for a complete description of the card or precede your comments with a dollar sign.

604 *** USER FATAL MESSAGE 604, THE ABØVE CARD HAS A NØNINTEGER IN AN INTEGER FIELD.

Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for legal values.

605 *** USER FATAL MESSAGE 605, A SYMSEQ OR SUBSEQ CARD APPEARS WITHØUT A SYMCØM ØR SUBCØM CARD.

SYMSEQ or SUBSEQ cards must appear in a subcase defined by a SYMCØM or SUBCØM card. Check your Case Control Deck order and relabel your combination subcase.

606 *** USER FATAL MESSAGE 606, A REQUEST FØR TEMPERATURE DEPENDENT MATERIALS ØCCURS AT THE SUBCASE LEVEL. ØNLY ØNE ALLOWED PER PRØBLEM.

Only one temperature field for materials is allowed per NASTRAN run. The last specified will be used for the entire run. If additional ones are desired, a modified restart is in order.

607 *** USER FATAL MESSAGE 607, A REPCASE SUBCASE MUST BE PRECEDED BY A SUBCASE ØR SYM SUBCASE.

A REPCASE subcase is an attempt to reoutput the previously computed case, therefore it cannot be the first subcase.

608 *** USER FATAL MESSAGE 608, THE SET ID SPECIFIED ØN THE ABØVE CARD MUST BE DEFINED PRIØR TO THIS CARD.

Set identification numbers must be specified prior to their use. Also sets specified within a subcase die at the end of the subcase. Redefine set (or define set) or move set out of subcase.

609 *** USER FATAL MESSAGE 609, SUBCASE DELIMITER CARDS MUST HAVE A UNIQUE IDENTIFYING INTEGER.

Subcase type cards must have an identifying integer. These numbers must be strictly increasing. Renumber your subcase cards. The use of a nonblank delimiter (e.g., "=") will also cause this message to occur.

610 *** USER FATAL MESSAGE 610, THE VALUE FØLLØWING THE EQUAL SIGN IS ILLEGAL.

Case control cannot identify the BCD value after the equal sign. Consult NASTRAN case control card descriptions, User's Manual Section 2.3, for a full description of the card.

611 *** USER FATAL MESSAGE 611, TEN CARDS HAVE ILLEGAL KEY WØRDS. NASTRAN ASSUMES BEGIN BULK CARD IS MISSING. IT WILL NØW PRØCESS YØUR BULK DATA.

Only ten key words may be misspelled. A common source of this error may be the omission of the ØUTPUT(PLØT) or ØUTPUT(XYØUT) delimiter cards.

612 *** USER FATAL MESSAGE 612, --LIST OF LEGAL CASE CØNTROL MNEMØNICS.

This message is caused by Messages 601 or 611.

690 *** USER FATAL ERRØR MESSAGE 690, TYPE ØF CURVE WAS NØT SPECIFIED. (E.G. DISPLACEMENT, STRESS, ETC.).

691 *** USER FATAL ERRØR MESSAGE 691, MØRE THAN 2 ØR UNEQUAL NUMBER ØF CØMPØNENTS FØR IDENTIFICATIØN NUMBERS WITHIN A SINGLE FRAME.

692 *** USER FATAL ERRØR MESSAGE 692, XY-ØUTPUT CØMMAND IS INCØMPLETE.

693 *** USER FATAL ERRØR MESSAGE 693, INSUFFICIENT CØRE FØR SET TABLE.

694 *** USER FATAL ERRØR MESSAGE 694, AUTØ ØR PSDF REQUESTS MAY NØT USE SPLIT FRAME, THUS ØNLY ØNE CØMPØNENT PER ID IS PERMITTED.

695 *** USER FATAL ERRØR MESSAGE 695, CØMPØNENT VALUE = **** IS ILLEGAL FØR AUTØ ØR PSDF VECTØR REQUESTS.

696 *** USER FATAL MESSAGE 696, CØMPØNENT VALUE = ******** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

969 *** USER FATAL ERROR MESSAGE 969, CØMPØNENT VALUE = **** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

975 *** USER WARNING MESSAGE 975, XYTRAN DØES NØT RECØGNIZE **** AND IS IGNØRING.

976 *** USER WARNING MESSAGE 976, ØUTPUT DATA BLØCK **** IS PURGED. XYTRAN WILL PRØCESS ALL REQUESTS ØTHER THAN PLØT.

977 *** USER WARNING MESSAGE 977, FØLLØWING NAMED DATA BLØCK IS NØT IN SØRT2 FØRMAT.

978 *** USER WARNING MESSAGE 978, XYTRAN MØDULE FINDS DATA BLØCK (****) PURGED, NULL, ØR INADEQUATE, AND IS IGNØRING XY-ØUTPUT REQUEST FØR - **** - CURVES.

979 *** USER WARNING MESSAGE 979, AN XY-ØUTPUT REQUEST FØR PØINT ØR ELEMENT ID **** - **** - CURVE IS BEING PASSED ØVER. THE ID CØULD NØT BE FØUND IN DATA BLØCK ****.

980 *** USER WARNING MESSAGE 980, INSUFFICIENT CØRE TØ HANDLE ALL DATA FØR ALL CURVES ØF THIS FRAME ID = **** CØMPØNENT = **** DELETED FRØM ØUTPUT.

981 *** USER WARNING MESSAGE 981, CØMPØNENT = **** FØR ID = **** IS TØØ LARGE. THIS CØMPØNENTS CURVE NØT ØUTPUT.

982 *** USER WARNING MESSAGE 982, FØRMAT ØF SDR3 INPUT DATA BLØCK **** DØES NØT PERMIT SUCCESSFUL SØRT2 PRØCESSING.

983 *** USER WARNING MESSAGE 983, SDR3 HAS INSUFFICIENT CØRE TØ PERFØRM SØRT2 ØN INPUT DATA BLØCK **** ØR DATA BLØCK IS NØT IN CØRRECT FØRMAT.

DIAGNOSTIC MESSAGES

984 *** USER WARNING MESSAGE 984, SDR3 FINDS ØUTPUT DATA BLØCK **** PURGED.

985 *** USER WARNING MESSAGE 985, SDR3 FINDS SCRATCH **** PURGED.

986 *** USER WARNING MESSAGE 986, INSUFFICIENT CØRE FØR SDR3.

991 *** USER WARNING MESSAGE 991, XYPLØT INPUT DATA FILE **** NØT FØUND. XYPLØT ABANDØNED.

The input data file probably has been purged and there were no plots to be done.

992 *** USER WARNING MESSAGE 992, XYPLØT INPUT DATA FILE I.D. RECØRDS TØØ SHØRT. XYPLØT ABANDØNED.

The input data file records have invalid word counts and further plotting is not feasible.

993 *** USER WARNING MESSAGE 993, XYPLØT FØUND ØDD NØ. ØF VALUES FØR DATA PAIRS IN FRAME ****, CURVE NØ. ****. LAST VALUE IGNØRED.

May indicate a bad input file, but plotting continues.

994 *** USER WARNING MESSAGE 994, XYPLØT ØUTPUT FILE NAME **** NØT FØUND. XYPLØT ABANDØNED.

A magnetic tape for plotting has not been properly set up and further plotting is useless.

995 *** USER WARNING MESSAGE 995, XYPLØT HAS ILLEGAL PLØTTER NUMBER = **** FRØM INPUT DATA FILE. PLØTTER NØ. **** ASSUMED.

Probable cause is the user not setting up the proper plotter number in the Case Control Deck. The plotting will be done on the plotter most commonly used at the installation.

996 *** USER WARNING MESSAGE 996, SPECIFIED PLØTTER PAPER SIZE TØØ SMALL. XYPLØT ASSUMES DIMENSIØN IS 8 INCHES.

Message is for table plotter only. Assumption is made that plotter paper will be at least as large as stated. In any event the table plotter will have an inch margin on all sides.

997 *** USER WARNING MESSAGE 997, NØ. ***. FRAME NØ. **** INPUT DATA INCØMPATIBLE. ASSUMPTIØNS MAY PRODUCE INVALID PLØT.

NØ. *** may take any value from 1 to 4 with the following meaning:

1. Specified X maximum equal X minimum. If this value is zero, then X maximum is set to 5.0 and X minimum to -5.0, otherwise 5 times the absolute value of X maximum is added to X maximum and subtracted from X minimum.
2. Specified X maximum is smaller than X minimum. The values are reversed.
3. Same meaning as number 1 except for Y maximum and Y minimum.
4. Same meaning as number 2 except for Y maximum and Y minimum.

6.2.2 Executive Module Messages

1001 *** SYSTEM FATAL MESSAGE 1001, ØSCAR NØT FØUND IN DPL.

ØSCAR file not present (destroyed) in Data Pool Dictionary.

1002 *** SYSTEM FATAL MESSAGE 1002, ØSCAR CØNTAINS NØ MØDULES.

XSFA found no modules on ØSCAR needing file allocation.

1003 *** SYSTEM FATAL MESSAGE 1003, PØØL CØULD NØT BE ØPENED.

Data Pool File (PØØL) not present (destroyed) in FIST.

1004 *** SYSTEM FATAL MESSAGE 1004, ILLEGAL EØF ØN PØØL.

End-Of-File encountered before ØSCAR file reached on Data Pool.

1011 *** SYSTEM FATAL MESSAGE 1011, MD ØR SØS TABLE ØVERFLØW.

Module description or serial ØSCAR table overflowed.

1012 *** SYSTEM FATAL MESSAGE 1012, PØØL CØULD NØT BE ØPENED.

Data Pool File (PØØL) not present (destroyed) in FIST.

1013 *** SYSTEM FATAL MESSAGE 1013, ILLEGAL EØR ØN PØØL.

ØSCAR record has illegal format.

1014 *** SYSTEM FATAL MESSAGE 1014, PØØL FILE MIS-POSITIØNED.

ØSCAR (PØØL) file not at position passed in XSFA calling sequence.

1021 *** SYSTEM FATAL MESSAGE 1021, FIAT ØVERFLØWED.

FIAT /XFIAT/ Table overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.

1031 *** SYSTEM FATAL MESSAGE 1031, DPL ØVERFLØW.

Data Pool Dictionary /XDPL/ overflowed - increase complied size. See Section 2 of the Programmer's Manual.

1032 *** SYSTEM FATAL MESSAGE 1032, PØØL ØR FILE BEING PØØLED/UN-PØØLED CØULD NØT BE ØPENED.

Files not present (destroyed) in FIST.

1033 *** SYSTEM FATAL MESSAGE 1033, ILLEGAL EØF ØN FILE BEING PØØLED.

File being pooled has illegal format.

1034 *** SYSTEM FATAL MESSAGE 1034, ILLEGAL EØR ØN FILE BEING PØØLED.

File being pooled has illegal format (bad header).

1035 *** SYSTEM FATAL MESSAGE 1035, EQUIV INDICATED, NØNE FØUND.

File (data block) equivalence not found as indicated by XSFA.

1041 *** SYSTEM FATAL MESSAGE 1041, ØLD/NEW PØØL CØULD NØT BE ØPENED.

Files not present (destroyed) in FIST.

1051 *** SYSTEM FATAL MESSAGE 1051, FIAT ØVERFLØW.

FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.

1101 *** USER FATAL MESSAGE 1101, CØULD NØT ØPEN FILE NAMED ********.

Data block has not been generated.

1102 *** SYSTEM FATAL MESSAGE 1102, CØULD NØT ØPEN FILE NAMED ********.

Problem Tape (NPTP) or Pool Table (PØØL) File linkage is broken. Look for error in /XFIST/, /XPFIST/ or /XXFIAT/.

1103 *** SYSTEM FATAL MESSAGE 1103, UNABLE TØ PØSITIØN DATA PØØL FILE CØRRECTLY.

Contents of /XDPL/ does not correspond to contents of PØØL file.

1104 *** SYSTEM FATAL MESSAGE 1104, FDICT TABLE IS INCORRECT.

Subroutine XCHK is not generating FDICT correctly.

1105 *** USER FATAL MESSAGE 1105, CANNØT FIND DATA BLØCK NAMED ******** HEADER RECØRD = ********.

Data block name or equivalenced data block name must match header record.

1106 *** USER FATAL MESSAGE 1106, CHECKPØINT DICTIØNARY ØVERFLØWED THERE IS NØ MØRE CØRE AVAILABLE.

Restart problem from this point with dictionary available.

1107 *** SYSTEM FATAL MESSAGE 1107, CANNØT FIT DATA BLØCK NAMED ******** ØN TWØ PRØBLEM TAPE REELS.

Use full tape reels for Problem Tape.

1108 *** SYSTEM FATAL MESSAGE 1108, PURGE TABLE ØVERFLØWED.

Reduce the number of data blocks being checkpointed at one time by replacing a single CHKPNT instruction with two CHKPNT instructions .

1109 *** SYSTEM FATAL MESSAGE 1109, CANNØT FIND DATA BLØCK NAMED NXPTDC HEADER RECØRD = ********.

Problem Tape is not positioned correctly for reading NXPTDC. Problem is in subroutine which previously wrote NXPTDC onto Problem Tape. Suspect modules are XGPI, XCEI or XCHK.

1201 *** SYSTEM FATAL MESSAGE 1201, FIAT ØVERFLØW.

FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2.4 of the Programmer's Manual.

1202 *** SYSTEM FATAL MESSAGE 1202, DPL ØVERFLØW.

Data Pool Dictionary /XDPL/ overflowed - increase compiled size. See Section 2.4 of the Programmer's Manual.

1701 *** SYSTEM WARNING MESSAGE 1701, AVAILABLE CØRE EXCEEDED BY ********* LINE IMAGE BLØCKS.

1702 *** SYSTEM INFØRMATIØN MESSAGE 1702, UTILITY MØDULE SEEMAT WILL ABANDØN PRØCESSING DATA BLØCK ********.

1703 *** USER WARNING MESSAGE 1703, PRECEDING BULK DATA DECK HAS BEEN CANCELED AND WILL NØT APPEAR ØN USER MASTER FILE.

The preceding Bulk Data Deck contains errors which preclude its inclusion on the User Master File. Appropriate error messages should appear in the echo of the Bulk Data Deck. Any subsequent Bulk Data Decks will be placed on the User Master File if error-free.

1704*** USER FATAL MESSAGE 1704, ILLEGAL TID VALUE ØN UMF CARD.

The TID value used on all UMF cards must be the same for any run and must match the TID value on the UMF tape being input. See Section 2.5 of the User's Manual for details.

1705 *** Reserved for future implementation in the User Master File Editor.

1706 *** Reserved for future implementation in the User Master File Editor.

1707 *** SYSTEM FATAL MESSAGE 1707, UMFEDT - UNEXPECTED EØF FROM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1708 *** SYSTEM FATAL MESSAGE 1708, UMFEDT - UNEXPECTED EØR FROM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1709 *** SYSTEM FATAL MESSAGE 1709, UMFEDT UNABLE TØ ØPEN ØNE ØF THE PERMANENT NASTRAN FILES UMF, NUMF, OR NPTP.

1710 *** Reserved for future implementation in the User Master File Editor.

1711 *** USER FATAL MESSAGE 1711, NØ TAPE SETUP FØR EITHER UMF ØR NUMF. THE USER MASTER FILE EDITØR REQUIRES AT LEAST ØNE ØF THESE TAPES TØ BE SET UP.

The tape(s) required must be appropriate to the requested action. See Section 2.5 of the User's Manual for details.

1712 *** Reserved for future implementation in the User Master File Editor.

1713 *** Reserved for future implementation in the User Master File Editor.

1714 *** Reserved for future implementation in the User Master File Editor.

1715 *** Reserved for future implementation in the User Master File Editor.

1716 *** Reserved for future implementation in the User Master File Editor.

1717 (1) *** USER WARNING MESSAGE 1717, REQUEST TØ ADD DECK WITH PRØBLEM IDENTIFICATIØN NØ. = **** CØNFLICTS WITH IMPLIED REQUEST TØ CØPY THE SAME PRØBLEM FRØM THE UMF. THE NEW DECK WILL BE USED.

This message will occur whenever a deck is added whose PID value is the same as that of a problem already existing on the old User Master File.

1717 (2) *** USER WARNING MESSAGE 1717, ILLEGAL PLØTTER SPECIFIED FØR SEEMAT (********).

1718 *** USER WARNING MESSAGE 1718, REMØVE REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1719 *** USER WARNING MESSAGE 1719, LIST REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

Use Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1720 (1) *** USER WARNING MESSAGE 1720, PUNCH REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1720 (2) *** USER WARNING MESSAGE 1720, PLØT FILE - **** NØT SET UP.

1721 *** USER FATAL MESSAGE 1721, PRØBLEM WITH PID = **** IS NØT ØN UMF ØR CARD IS ØUT ØF SEQUENCE.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1722 *** USER FATAL MESSAGE 1722, NUMF TAPE ID HAS ALREADY BEEN SPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1723 *** USER FATAL MESSAGE 1723, NUMF TAPE ID MAY NØT BE RESPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1724 (1) *** USER WARNING MESSAGE 1724, PUNPRT REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1724 (2) *** USER WARNING MESSAGE 1724, LØGIC ERRØR AT STATEMENT ***** IN SUBRØUTINE SEEMAT.

1725 *** Reserved for future implementation in the User Master File Editor.

1726 *** Reserved for future implementation in the User Master File Editor.

1727 *** Reserved for future implementation in the User Master File Editor.

1728 *** SYSTEM FATAL ERRØR 1728, UMFEDT UNABLE TØ LØCATE BULK DATA ØN NPTP.

1729 *** Reserved for future implementation in the User Master File Editor.

1730 *** Reserved for future implementation in the User Master File Editor.

1731 *** Reserved for future implementation in the User Master File Editor.

1732 *** Reserved for future implementation in the User Master File Editor.

1733 *** Reserved for future implementation in the User Master File Editor.

1734 *** Reserved for future implementation in the User Master File Editor.

1735 *** Reserved for future implementation in the User Master File Editor.

1736 *** USER FATAL ERRØR 1736, BAD USER MASTER FILE EDITØR DATA CARD.

See Section 2.5 of the User's Manual for instructions for using the User Master File Editor.

1737 *** Reserved for future implementation in the User Master File Editor.

1738 *** USER FATAL MESSAGE 1738, UTILITY MØDULE INPUT FIRST PARAMETER VALUE *** ØUT ØF RANGE.

In the test problem generating version of utility module INPUT, the first parameter value specifies the specific problem type as follows:

1. Laplace circuit (an N x N array of scalar points connected by scalar springs and optionally by scalar masses).
2. Rectangular frame made from BARs or RØDs.
3. Rectangular plate made from QUAD1 elements.

4. Rectangular plate made from TRIA1 elements.
5. N-segment string modeled with scalar elements.
6. N-cell beam made from BAR elements.
7. N-order full matrix generator with optional load.
8. N-spoke bicycle wheel.

1739 *** SYSTEM FATAL MESSAGE 1739, UNABLE TØ ØPEN FILE ***.

This message can occur if a required output file is purged in utility module INPUT.

1740 *** SYSTEM FATAL MESSAGE 1740, EØF ENCØUNTERED.

An unexpected End-Of-File has been encountered while reading an input data block in utility module INPUT.

1741 *** SYSTEM FATAL MESSAGE 1741, EØR ENCØUNTERED.

An unexpected End-Of-Logical Record indicator has been encountered while reading an input data block in utility module INPUT.

1742 *** SYSTEM FATAL MESSAGE 1742, NØ DATA PRESENT.

Utility module INPUT - input data block contains no data records.

1743 *** SYSTEM FATAL MESSAGE 1743, EØF FRØM FWDREC.

Utility module INPUT encountered an End-Of-File on an input data block while attempting to read past the header record.

1744 *** USER FATAL ERRØR 1744, DATA CARD(S) ******** GENERATED BY UTILITY MØDULE INPUT NØT ALLØWED IN BULK DATA.

Module is not capable of integrating same card type from two sources.

1745 **********************

Message 1745 is reserved for utility module input.

6.2.3 Functional Module Messages

2001 *** USER FATAL MESSAGE 2001, SEQGP CARD REFERENCES UNDEFINED GRID PØINT ****.

2002 *** SYSTEM FATAL MESSAGE 2002, GRID PØINT **** NØT IN EQEXIN.

This message indicates a program design error in GP1.

2003 *** USER FATAL MESSAGE 2003, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED GRID PØINT ****.

Applies to CØRD1j definitions.

2004 *** USER FATAL MESSAGE 2004, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

Applies to CØRD2j definitions.

2005 *** SYSTEM FATAL MESSAGE 2005, INCØNSISTENT CØØRDINATE SYSTEM DEFINITIØN.

At least one coordinate system cannot be tied to the basic system. See Section 4.21.7 of the Programmer's Manual.

2006 *** USER FATAL MESSAGE 2006, INTERNAL GRID PØINT **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

The grid point whose internal sequence number is printed above references an undefined coordinate system in either field 3 or field 7 of a GRID card.

2007 *** USER FATAL MESSAGE 2007, ELEMENT **** REFERENCES UNDEFINED GRID PØINT ****.

2008 *** USER FATAL MESSAGE 2008, LØAD SET **** REFERENCES UNDEFINED GRID PØINT ****.

2009 *** USER FATAL MESSAGE 2009, TEMP SET **** REFERENCES UNDEFINED GRID PØINT ****.

2010 *** USER FATAL MESSAGE 2010, ELEMENT **** REFERENCES UNDEFINED PRØPERTY ****.

2011 *** USER FATAL MESSAGE 2011, NØ PRØPERTY CARD FØR ELEMENT TYPE ****.

2012 *** USER FATAL MESSAGE 2012, GRID PØINT **** SAME AS SCALAR PØINT.

Identification of grid and scalar points must be unique.

2013 *** USER WARNING MESSAGE 2013, NØ STRUCTURAL ELEMENTS EXIST.

Model checked for structural elements.

2014 *** SYSTEM FATAL MESSAGE 2014, LØGIC ERRØR IN ECPT CØNSTRUCTIØN.

The spill logic in the construction of the skeleton (TA1B) has failed. Problem should be referred to maintenance programming staff. A temporary fix may be available if additional storage can be provided to NASTRAN e.g., by increasing the region size (IBM 360).

2015 *** USER WARNING MESSAGE 2015, NØ ELEMENTS CØNNECT INTERNAL GRID PØINT ****.

The grid point whose internal identification number appears above has no elements connected to it. The message is a warning only since the degrees of freedom associatea with the point may be removed by multipoint constraints or in other ways. The internal identification number is formed by assigning to each grid point and scalar point one of the integers 1, 2, --- according to its resequenced position. It may be determined from data block EQEXIN via a DMAP TABPT instruction.

2016 *** USER INFØRMATIØN MESSAGE 2016, GIVENS TIME ESTIMATE IS ******** SECØNDS.
(1) PRØBLEM SIZE IS ********, SPILL WILL ØCCUR FØR THIS CØRE AT A PRØBLEM SIZE ØF ******** .

2016 *** USER FATAL MESSAGE 2016, NØ MATERIAL PRØPERTIES EXIST.
(2)

2017 *** USER FATAL MESSAGE 2017, MATS1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATS1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2018 *** USER FATAL MESSAGE 2018, MATS2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATS2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2019 *** USER FATAL MESSAGE 2019, MATT1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATT1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2020 *** USER FATAL MESSAGE 2020, MATT2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATT2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2021 *** SYSTEM FATAL MESSAGE 2021, BAD GMMAT CALLING SEQUENCE.

The calling sequence of the subroutine which call either subroutine GMMATD or GMMATS defined a nonconformable matrix product. The subroutine examines the transpose flags in combination with the orders of the matrices to make sure that a conformable matrix product is defined by this input data. This test clearly is made for purposes of calling routine checkout only. No tests are made, nor can they be made, to insure that the calling routine has provided sufficient storage for arrays.

2022 *** SYSTEM FATAL MESSAGE 2022, SMA-B SCALAR PØINT INSERTIØN LØGIC ERRØR.

Problem error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2023 *** SYSTEM FATAL MESSAGE 2023, DETCK UNABLE TO FIND PIVØT POINT **** IN GPCT.

Probable error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2024 *** USER FATAL MESSAGE 2024, ØPERATIØN CØDE ******** NØT DEFINED FØR MØDULE PARAM.

The use of V,N,SUB rather than C,N,SUB can cause this.

2025 *** USER FATAL MESSAGE 2025, UNDEFINED CØØRDINATE SYSTEM ****.

The coordinate system identification number transmitted via ECPT(1) could not be found in the CSTM array. The user should check coordinate system numbers used on bulk data cards against those defined on CØRD1C, CØRD1R, etc., bulk data cards to insure that there are no undefined coordinate systems.

2026 *** USER FATAL MESSAGE 2026, ELEMENT **** GEØMETRY YIELDS UNREASØNABLE MATRIX.

Referenced element geometry and/or properties yields a numerical result which causes an element stiffness or mass matrix to be undefined. Possible causes include, but are not limited to, (1) the length of a rod or bar is zero because the end points have the same coordinates, (2) the sides of a triangle or quadrilateral are collinear which leads to a zero cross product in defining an element coordinate system, or (3) the bar orientation vector is parallel to the bar axis. Check GRID bulk data cards defining element end points for bad data.

2027 *** USER FATAL MESSAGE 2027, ELEMENT **** HAS INTERIØR ANGLE GREATER THAN 180 DEG. AT GRID PØINT ****.

SHEAR or TWIST panel element with the referenced element number has been defined with the four grid points out of the proper cyclical order. See bulk data card definitions for CSHEAR and CTWIST cards.

2028 *** SYSTEM FATAL MESSAGE 2028, SMA3A ERRØR NØ. ****.

Internal logic error in subroutine SMA3A of module SMA3. Possible error in generation of the GEI data block. Use the TABPT module to print GEI.

2029 *** USER FATAL MESSAGE 2029, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set had no default temperature defined. Define a temperature or default temperature for each grid point in the model.

2030 *** SYSTEM FATAL MESSAGE 2030, BAD GPTT.

The format of the GPTT data block is incorrect. Use the TABPT module to print the GPTT data block.

2031 *** USER FATAL MESSAGE 2031, ELEMENT **** UNACCEPTABLE GEØMETRY.

2032 *** USER FATAL MESSAGE 2032, ELEMENT **** UNACCEPTABLE GEØMETRY.

2033 *** USER FATAL MESSAGE 2033, SINGULAR H-MATRIX FØR ELEMENT ****.

2034 *** SYSTEM FATAL MESSAGE 2034, ELEMENT **** SIL'S DØ NØT MATCH PIVØT.

Possible error in generation of the ECPT data block. Use the TABPT module to print ECPT.

2035 *** USER FATAL MESSAGE 2035, QUADRILATERAL **** INTERIØR ANGLE GREATER THAN 180 DEG.

2036 *** USER FATAL MESSAGE 2036, SINGULAR MATRIX FØR ELEMENT ****.

2037 *** USER FATAL MESSAGE 2037, BAD ELEMENT **** GEØMETRY.

2038 *** SYSTEM FATAL MESSAGE 2038, SINGULAR MATRIX FØR ELEMENT ****.

2039 *** USER FATAL MESSAGE 2039, ZERØ SLANT LENGTH FØR HARMØNIC **** ØF CCØNEAX ****.

2040 *** USER FATAL MESSAGE 2040, SINGULAR MATRIX FØR ELEMENT ****.

2041 *** USER FATAL MESSAGE 2041, A MATT1,MATT2,MATT3 OR MATS1 CARD REFERENCES TABLE NUMBER **** WHICH IS NØT DEFINED ØN A TABLEM1, TABLEM2, TABLEM3, TABLEM4 ØR TABLES1 CARD.

The user must insure that all table identification numbers on MATT1, MATT2, MATT3, or MATS1 cards reference tables which exist in the Bulk Data Deck.

2042 *** USER FATAL MESSAGE 2042, MISSING MATERIAL TABLE **** FØR ELEMENT ****.

The referenced material table identification number is missing. The user should check to see that all element property bulk data cards (e.g., PBAR, PRØD) reference material card identification numbers for material property cards that exist in the Bulk Data Deck.

2043 (1) *** USER WARNING MESSAGE 2043, ØFP HAS INSUFFICIENT CØRE FØR ØNE GINØ BUFFER **** ØFP NØT EXECUTED.

2043 (2) *** USER FATAL MESSAGE 2043, MISSING MATERIAL TABLE ********.

2044 *** USER FATAL MESSAGE 2044, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set was selected in the Case Control Deck but not defined in the Bulk Data Deck.

2045 *** USER FATAL MESSAGE 2045, TEMPERATURE UNDEFINED AT GRID PØINT WITH INTERNAL INDEX ****.

Temperatures must be defined at all grid points in a selected temperature set. The grid point whose internal index was printed had no temperature defined and a default temperature was not supplied for the selected temperature set.

2046 *** USER FATAL MESSAGE 2046, UNDEFINED ELEMENT DEFØRMATIØN SET ****.

2047 *** USER FATAL MESSAGE 2047, UNDEFINED MULTIPØINT CØNSTRAINT SET ****.

A multipoint constraint set selected in the Case Control Deck could not be found in either an MPC or MPCADD card or a set referenced on a MPCADD card could not be found on an MPC card.

2048 *** USER FATAL MESSAGE 2048, UNDEFINED GRID PØINT **** IN MULTI-PØINT CØNSTRAINT SET ****.

2049 *** USER FATAL MESSAGE 2049, UNDEFINED GRID PØINT **** HAS AN ØMITTED CØØRDINATE.

An ØMIT or ØMIT1 card references a grid point which has not been defined.

2050 *** USER FATAL MESSAGE 2050, UNDEFINED GRID PØINT **** HAS A SUPPØRT CØØRDINATE.

A SUPØRT card references a grid point which has not been defined.

2051 *** USER FATAL MESSAGE 2051, UNDEFINED GRID PØINT **** IN SINGLE PØINT CØNSTRAINT SET ****.

An SPC1 card in the selected SPC set references a grid point which has not been defined.

2052 *** USER FATAL MESSAGE 2052, UNDEFINED GRID PØINT *** IN SINGLE-PØINT CØNSTRAINT SET ****.

An SPC card in the selected SPC set references a grid point which has not been defined.

2053 *** USER FATAL MESSAGE 2053, UNDEFINED SINGLE-PØINT CØNSTRAINT SET ****.

A single point constraint set selected in the Case Control Deck could not be found on either an SPCADD, SPC or SPC1 card, or a set referenced on an SPCADD card could not be found on either an SPC or SPC1 card.

2054 *** USER FATAL MESSAGE 2054, SUPER ELEMENT **** REFERENCES UNDEFINED SIMPLE ELEMENT ****.

2055 *** SYSTEM WARNING MESSAGE 2055, NØGØ FLAG IS ØN AT ENTRY TØ SMA1A AND IS BEING TURNED ØFF.

2056 *** USER FATAL MESSAGE 2056, UNDEFINED SUPER ELEMENT **** PRØPERTIES.

2057 *** USER FATAL MESSAGE 2057, IRRATIØNAL SUPER ELEMENT **** TØPØLØGY.

2058 *** USER WARNING MESSAGE 2058, ELEMENT ********** CONTRIBUTES TO THE DAMPING MATRIX WHICH IS PURGED. IT WILL BE IGNORED.

2059 *** USER FATAL MESSAGE 2059, UNDEFINED GRID PØINT **** ØN SE--BFE FØR SUPER ELEMENT ****.

2060 *** USER FATAL MESSAGE 2060, UNDEFINED GRID PØINT **** ØN QDSEP CARD FØR SUPER ELEMENT ****.

2061 *** USER FATAL MESSAGE 2061, UNDEFINED GRID PØINT **** ØN GENERAL ELEMENT ****.

2062 *** USER FATAL MESSAGE 6062, UNDEFINED SUPER ELEMENT PRØPERTY **** FØR SUPER ELEMENT ****.

2063 *** SYSTEM FATAL MESSAGE 2063, TA1C LØGIC ERRØR. GENERAL ELEMENT DATA CØULD NØT BE FØUND IN THE ECT DATA BLØCK WHEN TRAILER LIST INDICATED IT WAS PRESENT. REFER PRØBLEM TO MAINTENANCE PRØGRAMMING STAFF.

2064 *** USER FATAL MESSAGE 2064, UNDEFINED EXTRA PØINT **** REFERENCED ØN SEQEP CARD.

2065 *** USER FATAL MESSAGE 2065, UNDEFINED GRID PØINT **** ØN DMIG CARD.

2066 *** USER FATAL MESSAGE 2066, UNDEFINED GRID PØINT **** ØN RLØAD- ØR TLØAD- CARD.

2067 *** USER FATAL MESSAGE 2067, UNDEFINED GRID PØINT **** ØN NØLIN- CARD.

2068 *** USER FATAL MESSAGE 2068, UNDEFINED GRID PØINT **** IN TRANSFER FUNCTIØN SET ****.

2069 *** USER FATAL MESSAGE 2069, UNDEFINED GRID PØINT **** IN TRANSIENT INITIAL CØNDITION SET ****.

2070 *** USER FATAL MESSAGE 2070, REQUESTED DMIG MATRIX **** IS UNDEFINED.

2071 *** USER FATAL MESSAGE 2071, DYNAMIC LØAD SET **** REFERENCES UNDEFINED TABLE ****.

2072 *** SYSTEM WARNING MESSAGE 2072, CARD TYPE *** NØT FØUND ØN DATA BLØCK.

This warning message is issued when the trailer bit for the card type = 1 but the corresponding record is not on the data block.

2073 *** USER INFØRMATIØN MESSAGE 2073, MPYAD METHØD = ****, NØ. ØF PASSES = ****.

This message gives the method selected and number of passes required.

2074 *** USER FATAL MESSAGE 2074, UNDEFINED TRANSFER FUNCTIØN SET ****.

2075 *** SYSTEM ØR USER DMAP FATAL MESSAGE 2075, IMPRØPER VALUE **** FØR FIRST PARAMETER IN DMAP INSTRUCTIØN SDR2.

2076 *** USER WARNING MESSAGE 2076, SDR2 ØUTPUT DATA BLØCK NØ. 1 IS PURGED.

2077 *** USER WARNING MESSAGE 2077, SDR2 ØUTPUT DATA BLØCK NØ. 2 IS PURGED.

2078 *** USER WARNING MESSAGE 2078, SDR2 ØUTPUT DATA BLØCK NØ. 3 IS PURGED.

2079 *** USER WARNING MESSAGE 2079, SDR2 FINDS THE -EDT-, -EST-, ØR -GPTT- PURGED ØR INADEQUATE AND IS THUS NØT PRØCESSING ANY REQUESTS FØR STRESSES ØR FØRCES.

2080 *** USER WARNING MESSAGE 2080, SDR2 ØUTPUT DATA BLØCK NØ. 6 IS PURGED.

2081 *** USER FATAL MESSAGE 2081, NULL DIFFERENTIAL STIFFNESS MATRIX.

Differential stiffness is not defined for all structural elements. Only the following elements are defined for differential stiffness calculations: RØD, TUBE, SHEAR (but not TWIST) panels, triangular and quadrilateral membranes (TRMEM, TRIA2, QDMEM, QUAD2), and BAR. The combination two dimensional elements TRIA1 and QUAD1, are defined only if their membrane thickness is nonzero. The user has not included any of these elements in his model and therefore a null differential stiffness matrix was generated.

2083 *** USER FATAL MESSAGE 2083, NULL DISPLACEMENT VECTØR.

The displacement vector for the linear solution part of a static analysis with differential stiffness problem, or the incremental displacement vector in a piecewise linear analysis rigid format problem is the zero vector. Check loading conditions.

2084 *** SYSTEM FATAL MESSAGE 2084, DSMG2 LØGIC ERRØR ****.

Incompatible input and output pairs in the DMAP calling sequence to module DSMG2. See the module description for DSMG2 in the Programmer's Manual.

2085 *** USER INFØRMATIØN MESSAGE 2085, **** SPILL, NPVT ****.

During processing of the ECPT data block in module ****, so many elements were attached to the referenced pivot point (NPVT) that module spill logic was initiated.

2086 *** USER INFØRMATIØN MESSAGE 2086, SMA2 SPILL, NPVT ****.

See explanation for Message 2085.

2087 *** SYSTEM FATAL MESSAGE 2087, ECPT CØNTAINS BAD DATA.

Use the TABPT module to print the ECPT data block.

2088 *** USER FATAL MESSAGE 2088, DUPLICATE TABLE ID ****.

All tables must have unique numbers. Check for uniqueness.

2089 *** USER FATAL MESSAGE 2089, TABLE **** UNDEFINED.

The table number in the list of table numbers input to subroutine PRETAB via argument 7 was not found after reading the DIT data block. Check list of tables in the Bulk Data Deck.

2090 *** SYSTEM FATAL MESSAGE 2090, TABLE DICTIØNARY ENTRY **** MISSING.

Logic error in subroutine PRETAB, or open core used by PRETAB has been destroyed.

2091 *** SYSTEM FATAL MESSAGE 2091, PLA3, BAD ESTNL EL ID ****.

ESTNL data block is not in expected format. Use TABPT module to print the ESTNL data block.

2092 *** SYSTEM WARNING MESSAGE 2092, SDR2 FINDS A SYMMETRY SEQUENCE LENGTH = **** AND AN INSUFFICIENT NUMBER ØF VECTØRS AVAILABLE = **** WHILE ATTEMPTING TØ CØMPUTE STRESSES AND FORCES. ALL FURTHER STRESS AND FØRCES CØMPUTATIØN TERMINATED.

2093 *** USER FATAL MESSAGE 2093, NØLIN CARD FRØM NØLIN SET **** REFERENCES GRID PØINT **** UD SET.

2094 *** USER WARNING MESSAGE 2094, SUBRØUTINE TABFMT, KEYNAME ******** NØT IN RECØGNIZED LIST. A PRINTØUT ØF THE RECØGNIZED LIST ØF KEYNAMES FØLLØWS.

2095 *** USER WARNING MESSAGE 2095, SUBRØUTINE TABFMT, PURGED INPUT.

2096 *** USER WARNING MESSAGE 2096, SUBRØUTINE TABFMT, EØF ENCØUNTERED.

2097 *** USER WARNING MESSAGE 2097, SUBRØUTINE TABFMT, EØR ENCØUNTERED.

2098 *** USER WARNING MESSAGE 2098, SUBRØUTINE TABFMT, INSUFFICIENT CØRE.

2099 *** USER WARNING MESSAGE 2099, SUBRØUTINE TABFMT, KF **********.

2101A *** USER FATAL MESSAGE 2101A, GRID PØINT **** CØMPØNENT *** ILLEGALLY DEFINED IN SETS ****.

The above grid point and component has been defined in each of the above dependent subsets. A point may belong to at most one dependent subset.

2101B *** USER FATAL MESSAGE 2101B, SCALAR PØINT **** ILLEGALLY DEFINED IN SETS ****.

2102 *** USER WARNING MESSAGE 2102, LEFT-HAND MATRIX RØW PØSITIØN **** ØUT ØF RANGE - IGNØRED.

A term in the A matrix whose row position is larger than the stated dimension was detected and ignored.

2103 *** SYSTEM FATAL MESSAGE 2103, SUBRØUTINE MAT WAS CALLED WITH INFLAG=2, THE SINE ØF ANGLE X, MATERIAL ØRIENTATIØN ANGLE, NØNZERØ, BUT SIN(X)**2+CØS(X)**2 DIFFERED FRØM 1 IN ABSOLUTE VALUE BY MØRE THAN .0001.

A check is made in MAT to insure that ABS(SIN(THETA)**2+CØS(THETA)**2-1.00) .LE. .0001 when INFLAG = 2. The calling routine did not set SINTH and CØSTH cells in /MATIN/ properly.

2104 *** USER FATAL MESSAGE 2104, UNDEFINED CØØRDINATE SYSTEM ****.

See the explanation for Message 2025.

2105 *** USER FATAL MESSAGE 2105, PLØAD2 CARD FRØM LØAD SET **** REFERENCES MISSING ØR NØN-2-D ELEMENT ****.

PLØAD2 cards must reference two-dimensional elements.

2106 *** USER FATAL MESSAGE 2106, LØAD CARD DEFINES NØNUNIQUE LØAD SET ****.

2107 *** USER FATAL MESSAGE 2107, EIG-CARD FRØM SET **** REFERENCES DEPENDENT CØØRDINATE ØR GRID PØINT ****.

When the point option is used on an EIGB, EIGC or EIGR card, the referenced point and component must be in the analysis set for use in normalization.

2108 *** USER FATAL MESSAGE 2108, NØ XY-PLØTTER HAS BEEN SPECIFIED TØ THIS PØINT.

2109 *** USER FATAL MESSAGE 2109, NØ GRID, SCALAR ØR EXTRA PØINTS DEFINED.

2110 *** USER WARNING MESSAGE 2110, INSUFFICIENT CØRE TØ HØLD CØNTENTS ØF GINØ FILE *** FURTHER PRØCESSING ØF THIS DATA BLØCK IS ABANDØNED.

2111 *** USER WARNING MESSAGE 2111, BAR **** CØUPLED BENDING INERTIA SET TØ 0.0 IN DIFFERENTIAL STIFFNESS.

The coupled bending inertia term on a PBAR card, if nonzero, is set to zero in the differential stiffness routine for the BAR.

2112 *** SYSTEM FATAL MESSAGE 2112, UNDEFINED TABLE ****.

The referenced table number could not be found in core.

2113 *** USER FATAL MESSAGE 2113, MATERIAL ****, A NØN-MAT1 TYPE, IS NØT ALLØWED TØ BE STRESS DEPENDENT.

Only MAT1 material cards may be present in a piecewise linear analysis problem.

2114 *** USER FATAL MESSAGE 2114, MATT3 CARD REFERENCES UNDEFINED MAT3 **** CARD.

The user should check that all MATT3 cards reference MAT3 cards that exist in the Bulk Data Deck. This can also happen if ID noted by **** could not be found on MAT1 card (see Message 2042).

2115 *** USER FATAL MESSAGE 2115, TABLE **** (TYPE ****) ILLEGAL WITH STRESS-DEPENDENT MATERIAL.

Only TABLES1 cards may be used to define stress-strain curves for use in piecewise linear analysis.

2116 *** SYSTEM FATAL MESSAGE 2116, MATID **** TABLEID ****.

The referenced material table identification number could not be found among the set of all MAT1 cards in core.

2117 *** USER FATAL MESSAGE 2117, TEMPERATURE DEPENDENT MATERIAL PRØPERTIES ARE NØT PERMISSIBLE IN A PIECEWISE LINEAR ANALYSIS PRØBLEM. TEMPERATURE SET = ****.

User should redefine his problem without temperature dependent material properties.

2118 *** USER INFØRMATIØN MESSAGE 2118, SUBRØUTINE GP4PRT, - DIAG 21 SET-DØF VS. DISP SETS FØLLØWS.

2119 *** USER INFØRMATIØN MESSAGE 2119, SUBRØUTINE GP4PRT, - DIAG 22 SET-DISP SETS VS. DØF FØLLØWS.

2120 *** USER FATAL MESSAGE 2120, MØDULE VEC - BØTH SUBSET BITS ARE NØN-ZERØ. I **********.

2121 *** USER FATAL MESSAGE 2121, MØDULE VEC - BØTH SUBSET BITS ARE ZERØ. I **********.

2122 *** USER FATAL MESSAGE 2122, MØDULE VEC - SET X BIT IS ZERØ BUT SUBSET X0 BIT IS NØT. I **********.

2123 *** USER FATAL MESSAGE 2123, MØDULE VEC - SET X BIT IS ZERØ BUT SUBSET X1 BIT IS NØT. I **********.

2124 *** USER WARNING MESSAGE 2124, MØDULE VEC - NR=0, ØUTPUT WILL BE PURGED.

2125 *** USER WARNING MESSAGE 2125, MØDULE VEC - NZ=0, ØUTPUT WILL BE PURGED.

2126 *** USER FATAL MESSAGE 2126, MØDULE VEC UNABLE TØ ØPEN GINØ FILE **** DATA BLØCK ********.
(1)

2126 *** USER FATAL MESSAGE 2126, UNDEFINED MATERIAL FØR ELEMENT ********.
(2)

2127 *** SYSTEM FATAL MESSAGE 2127, PLA2 INPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks DELTAUGV and DELTAPG cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2128 *** SYSTEM FATAL MESSAGE 2128, PLA2 ØUTPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks UGV1, PGV1 cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2129 *** SYSTEM FATAL MESSAGE 2129, PLA2, ZERØ VECTØR ØN APPENDED DATA BLØCK NØ. ****.

Zero displacement vector found on UGV1 data block output from PLA2. Possible system failure.

2130 *** USER FATAL MESSAGE 2130, ZERØ INCREMENTAL DISPLACEMENT VECTØR NØT ADMISSIBLE AS INPUT TØ MØDULE PLA2.

See discussion of the Piecewise Linear Analysis rigid format.

2131 *** USER FATAL MESSAGE 2131, NØN-SCALAR ELEMENT *** REFERENCES A SCALAR PØINT.

An element which must be attached to a geometric grid point has been attached to a scalar point. No geometry data can be inferred.

2132 *** USER FATAL MESSAGE 2132, NØN-ZERØ SINGLE PØINT CONSTRAINT VALUE SPECIFIED BUT DATA BLØCK YS IS PURGED.

Many rigid formats do not support constrained displacements (especially dynamic solutions). An attempt to specify a constrained displacement in these cases results in this message.

2133 *** USER FATAL MESSAGE 2133, INITIAL CØNDITIØN IN SET **** SPECIFIED FØR PØINT NØT IN ANALYSIS SET.

Initial conditions can only be specified for analysis set points. Therefore the point/component mentioned on TIC cards must belong to the D or H sets.

2134 *** USER FATAL MESSAGE 2134, LØAD SET *** DEFINED FØR BØTH GRAVITY AND NØN-GRAVITY LØADS.

The same load set identification number cannot appear on both a GRAV card and another loading card such as FØRCE or MØMENT. To apply both a gravity load and a concentrated load simultaneously the LØAD card must be used.

2135 *** USER FATAL MESSAGE 2135, DLØAD CARD *** HAS A DUPLICATE SET ID FOR SET ID ***.

The Li set ID's on a DLØAD card are not unique. See DLØAD card description in the User's Manual.

2136 *** USER FATAL MESSAGE 2136, SET ID *** HAS BEEN DUPLICATED ØN A DLØAD, RLØAD1,2 or TLØAD1,2 CARD.

All dynamic load set ID's must be unique.

2137 *** USER FATAL MESSAGE 2137, PRØGRAM RESTRICTIØN FØR MØDULE SSG1 - ØNLY 100 LØAD SET ID'S ALLØWED. DATA CØNTAINS **** LØAD SET ID'S.

Reduce the number of Load Set ID's.

2138 *** USER FATAL MESSAGE 2138, ELEMENT IDENTIFICATION NUMBER **** IS TØØ LARGE.

Element identification numbers (on connection cards) must be less than 16,777,215.

2139 *** USER FATAL MESSAGE 2139, ELEMENT **** IN DEFØRM SET **** IS UNDEFINED.

A selected element deformation set includes an element twice, includes a non-existent element, or includes a non-one-dimensional element.

2140 *** USER FATAL MESSAGE 2140, GRID PØINT ØR SCALAR PØINT ID *** IS TØØ LARGE.

Program restriction on the size of integer numbers. A card defining a grid point or scalar point has a number larger than 2,000,000.

2141 *** USER FATAL MESSAGE 2141, MØDULE VEC - EØF ENCØUNTERED WHILE READING GINØ FILE **** DATA BLØCK ********.

2142 *** USER FATAL MESSAGE 2142, INSUFFICIENT CØRE FØR MØDULE VEC. AVAILABLE CØRE = ********** WØRDS. ADDITIONAL CØRE NEEDED = ********** WØRDS.

2143 *** USER FATAL MESSAGE 2143, MØDULE VEC UNABLE TØ IDENTIFY SET ØR SUBSET DESCRIPTØR ********.

2144 *** USER FATAL MESSAGE 2144, MØDULE VEC - EØF ENCØUNTERED DURING FWDREC ØF GINØ FILE **** DATA BLØCK ********.

2145 *** USER FATAL MESSAGE 2145, ******** FATAL MESSAGES HAVE BEEN GENERATED IN SUBRØUTINE VEC. ØNLY THE FIRST **** HAVE BEEN PRINTED.

2146 *** USER FATAL MESSAGE 2146, BØTH ØF THE SECØND AND THIRD VEC PARAMETERS REQUEST CØMPLEMENT.

2147 *** SYSTEM FATAL MESSAGE 2147, ILLEGAL ELEMENT TYPE = ********** ENCØUNTERED BY DSMG MØDULE.

2150 *** USER FATAL MESSAGE 2150, ILLEGAL VALUE FØR FØURTH PARAMETER = **********.

2151 *** USER WARNING MESSAGE 2151, -PLAARY- ARRAY IS SMALLER THAN MAXIMUM NUMBER ØF ELEMENT TYPES.

2152 *** USER FATAL MESSAGE 2152, GRID PØINT ******** CØMPØNENT ** DUPLICATELY DEFINED IN THE **** SET.

2153 *** USER FATAL MESSAGE 2153, SCALAR PØINT ******** DUPLICATELY DEFINED IN THE **** SET.

2154 *** USER WARNING MESSAGE 2154, ZERØ AREA ØR ILLEGAL CØNNECTIØN FØR HBDY ELEMENT NUMBER ********.

2155 *** USER WARNING MESSAGE 2155, MAT4 AND MAT5 MATERIAL DATA CARDS HAVE SAME ID = ************** MAT4 DATA WILL BE SUPPLIED WHEN CALLED FØR THIS ID.

2156 *** SYSTEM FATAL MESSAGE 2156, ILLEGAL INFLAG = ************** RECEIVED BY HMAT.

2157 *** USER FATAL MESSAGE 2157, MATERIAL ID = ************** DØES NØT APPEAR ØN ANY MAT4 ØR MAT5 MATERIAL DATA CARD.

2158 *** SYSTEM WARNING MESSAGE 2158, A TRAPRG ELEMENT = ************** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

2159 *** USER FATAL MESSAGE 2159, TRIRG ØR TRAPRG ELEMENT = ************** PØSSESSES ILLEGAL GEØMETRY.

2160 *** USER FATAL MESSAGE 2160, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ******************.

2161 *** SYSTEM WARNING MESSAGE 2161, PARTITIØN FILE, **** IS ØF SIZE ********** RØWS BY ********** CØLS. PARTITIØNING VECTØRS INDICATE THAT THIS PARTITIØN SHØULD BE ØF SIZE ********** RØWS BY ********** CØLUMNS FØR A SUCCESSFUL MERGE.

2162 *** SYSTEM WARNING MESSAGE 2162, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE IS INCØNSISTENT WITH THE SIZE ØF THE MERGED MATRIX, HØWEVER IT HAS BEEN USED. FØRM = **********, SIZE = ********** RØWS BY ********** CØLUMNS.

2163 *** SYSTEM WARNING MESSAGE 2163, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET, ØR IS ØF ILLEGAL VALUE. THE FØRM ØF THE MERGED MATRIX HAS BEEN SET = **********.

2164 *** SYSTEM WARNING MESSAGE 2164, THE TYPE PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE MERGED MATRIX HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2165 *** USER FATAL MESSAGE 2165, ILLEGAL GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ******************.

2166 *** SYSTEM WARNING MESSAGE 2166, MATRIX TØ BE PARTITIØNED IS ØF SIZE ********** RØWS BY ********** CØLUMNS. RØW PARTITIØN SIZE IS ********** CØLUMN PARTITIØN SIZE IS ********** (INCØMPATIBLE).

2167 *** SYSTEM WARNING MESSAGE 2167, THE TYPE PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE PARTITIØNS HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2168 *** SYSTEM WARNING MESSAGE 2168, THE FØRM PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** IS INCØNSISTENT WITH ITS SIZE. FØRM = **********, SIZE = ********** ROWS BY ********** CØLUMNS.

2169 *** SYSTEM WARNING MESSAGE 2169, THE FØRM PARAMETERS AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. IT HAS BEEN RESET = **********.

2170 *** SYSTEM FATAL MESSAGE 2170, BØTH THE RØW AND CØLUMN PARTITIØNING VECTØRS ARE PURGED AND ØNLY ØNE MAY BE.

2171 *** SYSTEM WARNING MESSAGE 2171, SYM FLAG INDICATES TØ THE PARTITIØN ØR MERGE MØDULE THAT A SYMMETRIC MATRIX IS TØ BE ØUTPUT. THE PARTITIØNING VECTØRS ******** HØWEVER DØ NØT CØNTAIN AN IDENTICAL NUMBER ØF ZERØS AND NØN-ZERØS.

2172 *** SYSTEM WARNING MESSAGE 2172, RØW AND CØLUMN PARTITIØNING VECTØRS DØ NØT HAVE IDENTICAL ØRDERING ØF ZERØ AND NØN-ZERØ ELEMENTS, AND SYM FLAG INDICATES THAT A SYMMETRIC PARTITIØN ØR MERGE IS TØ BE PERFØRMED.

2173 *** SYSTEM WARNING MESSAGE 2173, PARTITIØNING VECTØR FILE **** CØNTAINS ********** CØLUMNS. ØNLY THE FIRST CØLUMN IS BEING USED.

2174 *** SYSTEM WARNING MESSAGE 2174, PARTITIØNING VECTØR ØN FILE **** IS NØT REAL-SINGLE ØR REAL-DØUBLE PRECISIØN.

2175 *** SYSTEM FATAL MESSAGE 2175, THE RØW PØSITIØN ØF AN ELEMENT ØF A CØLUMN ØN FILE **** IS GREATER THAN NUMBER ØF RØWS SPECIFIED BY TRAILER.

2176 *** SYSTEM FATAL MESSAGE 2176, FILE **** EXISTS BUT IS EMPTY.

2177 *** USER INFØRMATIØN MESSAGE 2177, SPILL WILL ØCCUR IN SYMMETRIC CØMPLEX DECØMPØSITIØN.

2178 *** SYSTEM FATAL MESSAGE 2178, GINØ REFERENCE NAMES, IMPRØPER FØR SUBRØUTINE FILSWI.

2179 *** SYSTEM FATAL MESSAGE 2179, ERRØR DETECTED IN FUNCTIØN FØRFIL ****, **** NØT IN FIST.

2180 *** USER WARNING MESSAGE 2180, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2181 *** SYSTEM FATAL MESSAGE 2181, SCDCMP CALLED TØ SØLVE A 1X1 ØR 2X2 MATRIX.

2182 *** USER WARNING MESSAGE 2182, SUBRØUTINE ******** IS DUMMY. ØNLY ØNE ØF THESE MESSAGES WILL APPEAR PER ØVERLAY ØF THIS DECK.

2183 *** USER WARNING MESSAGE 2183, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2184 *** SYSTEM WARNING MESSAGE 2184, STRESS ØR FØRCE REQUESTS FØR ELEMENT TYPE = **************** WILL NØT BE HØNØRED AS THIS ELEMENT IS UNDEFINED TØ SDR2.

2187 *** USER FATAL MESSAGE 2187, INSUFFICIENT WØRKING CØRE TØ HØLD FØRTRAN LØGICAL RECØRD.
LENGTH ØF WØRKING CØRE = **********.
LENGTH ØF FØRTRAN LØGICAL RECØRD = **********.

2188 *** USER INFØRMATIØN MESSAGE 2188, UNUSED CØRE = ********** WØRDS.

2189 *** USER INFØRMATIØN MESSAGE 2189, ADDITIØNAL CØRE REQUIRED TØ AVØID SPILL = ********** (DECIMAL) WØRDS.

2190 *** SYSTEM FATAL MESSAGE 2190, ILLEGAL VALUE FØR KEY = **********. EXPECTED VALUE = **********.

2191 *** USER WARNING MESSAGE 2191, ELEMENT TYPE ********** IS PRESENT AND IS BEING IGNØRED BY SMA1 SINCE ØPTIØN PARAM = ********.

2193 *** USER FATAL MESSAGE 2193, A REDUNDANT SET ØF RIGID BØDY MØDES WAS SPECIFIED FØR THE GENERAL ELEMENT.

Only a non-redundant list of rigid body modes is allowed to appear in the u_d set when the S matrix is to be internally calculated in subroutine TA1CA.

2194 *** USER FATAL MESSAGE 2194, A MATRIX D IS SINGULAR IN SUBRØUTINE TA1CA.

While attempting to calculate the [S] matrix for a general element in TA1CA, it was discovered that the matrix D_d which relates $\{u_b\}$ to $\{u_d\}$ was singular and could not be inverted.

2195 *** USER WARNING MESSAGE 2195, ILLEGAL VALUE FØR P4 = ******.

2196 *** USER WARNING MESSAGE 2196, DUMMY SUBRØUTINE TIMTS3.
DUMMY SUBRØUTINE TIMTS4.
DUMMY SUBRØUTINE TIMTS5.

2197 *** SYSTEM FATAL MESSAGE 2197, ABØRT CALLED DURING TIME TEST ØF *********.

2198 *** SYSTEM FATAL MESSAGE 2198, INPUT DATA BLØCK, ******** HAS BEEN PURGED.

2199 *** SYSTEM FATAL MESSAGE 2199, SUMMARY/ ØNE ØR MØRE ØF THE ABØVE FATAL ERRØRS WAS ENCØUNTERED IN SUBRØUTINE ********.

2251 *** USER WARNING MESSAGE 2251, PHYSICALLY UNREALISTIC VALUE FØR NU ØN MAT1 CARD ********.
VALUE = ****************.

3001 *** SYSTEM FATAL MESSAGE 3001, ATTEMPT TØ ØPEN DATA SET *** IN SUBRØUTINE ****** WHICH WAS NØT DEFINED IN FIST.

Subroutine did not expect data block to be purged. Check data block requirements for module.

3002 *** SYSTEM FATAL MESSAGE 3002, EØF ENCØUNTERED WHILE READING DATA SET ********(FILE ***) IN SUBRØUTINE ******.

This message is issued when an End-Of-File occurs while trying to skip the header record. The data block is not in the proper format.

3003 *** SYSTEM FATAL MESSAGE 3003, ATTEMPT TØ READ PAST THE END ØF A LØGICAL RECØRD IN DATA SET ********(FILE ***) IN SUBRØUTINE ********.

This message is issued when the file is positioned at the beginning of a logical record and the record does not contain at least three words. Data block is not in proper format.

3004 *** SYSTEM FATAL MESSAGE 3004, INCØNSISTANT TYPE FLAGS ENCØUNTERED WHILE PACKING DATA SET ****.

3005 *** USER FATAL MESSAGE 3005, ATTEMPT TØ ØPERATE ØN SINGULAR MATRIX **** IN SUBRØUTINE ****.

A diagonal term does not exist for a column of (U). This is normally detected in DECØMP implying care was not taken in processing singular matrices in the calling routine.

3006 *** SYSTEM FATAL MESSAGE 3006, BUFFER ASSIGNED WHEN ØPENING DATA BLØCK **** FILE (****) CØNFLICTS WITH BUFFERS CURRENTLY ØPEN.

Computation of buffer pointers or allocation of open core is in error.

3007 *** SYSTEM FATAL MESSAGE 3007, ILLEGAL INPUT TØ SUBRØUTINE ****.

Subroutine **** has encountered data which it cannot process. This error should not be caused by user input data. A system or programming error is indicated. Go directly to the subroutine listing or description to determine the exact cause of the problem.

3008 *** SYSTEM FATAL MESSAGE 3008, INSUFFICIENT CØRE AVAILABLE FØR SUBRØUTINE ********.

This message implies that the particular subroutine does not have sufficient core to meet its demands. The subroutine or module description should be consulted to determine the core requirements.

3009 *** SYSTEM FATAL MESSAGE 3009, DATA TRANSMISSIØN ERRØR ØN DATA SET *******(FILE ***).

IBM 7094, IØEX detected a data transmission error during GINØ READ.

3010 *** SYSTEM FATAL MESSAGE 3010, ATTEMPT TØ MANIPULATE DATA SET ********(FILE ***) BEFØRE ØPENING FILE.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

3011 *** SYSTEM FATAL MESSAGE 3011, ATTEMPT TØ WRITE A TRAILER ØN FILE *** WHEN IT HAS BEEN PURGED.

The file did not exist in the FIST when WRTTRL was called.

3012 *** SYSTEM FATAL MESSAGE 3012, ATTEMPT TØ ØPEN DATA SET ********(FILE ***) WHICH HAS ALREADY BEEN ØPENED.

IBM 7094 GINØ ØPEN was called while the file was already open.

3013 *** SYSTEM FATAL MESSAGE 3013, ATTEMPT TØ READ DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR ØUTPUT.

IBM 7094 GINØ was called to READ a data block opened for output.

3014 *** SYSTEM FATAL MESSAGE 3014, ATTEMPT TØ WRITE DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR INPUT.

IBM 7094 GINØ was called to WRITE a data block opened for input.

3015 *** SYSTEM FATAL MESSAGE 3015, ATTEMPT TØ FWDREC ØN DATA SET ********(FILE ***) WHEN IT WAS ØPENED FØR ØUTPUT.

IBM 7094 GINØ was called to FWDREC a file opened for output.

3016 *** SYSTEM FATAL MESSAGE 3016, **** MATRIX IS NØT IN PRØPER FØRM IN SUBRØUTINE ****.

This implies that the input matrix is not in the proper form or type acceptable to the subroutine. Check the trailer information on the matrix and the subroutine description for the discrepancy.

3017 *** USER WARNING MESSAGE 3017, ØNE ØR MØRE GRID PØINT SINGULARITIES HAVE NØT BEEN REMØVED BY SINGLE ØR MULTI-PØINT CØNSTRAINTS.

Singularities or near singularities may exist at the grid point level. The listed singularities should be examined for data errors. The check performed here is neither necessary nor sufficient for a singular matrix.

3018 *** SYSTEM FATAL MESSAGE 3018, MØDULE ********, SEQUENCE NØ. ***, REQUIREMENTS EXCEED AVAILABLE FILES.

Segment File Alloctor (SFA) did not have sufficient logical files available to fill the request of the module. Cut module requirements or increase the logical files within the computer system. See Section 5 of the Programmer's Manual.

3019 *** USER FATAL MESSAGE 3019, MAXIMUM LINE CØUNT EXCEEDED IN SUBRØUTINE **** LINE CØUNT EQUALS ****.

The total number of lines written on the system output file has exceeded the set limit (default value is 20,000). If you wish to increase this value, include a card of the form "MAXLINES=n" in your Case Control Deck.

3020 *** SYSTEM FATAL MESSAGE 3020, GNFIST ØVERFLØWED FIST TABLE AT SEQUENCE NØ. *** DATA SET ********.

Generate FIST (GNFIST) routine overflowed FIST /XFIST/. Increase complied size. See Section 2 of the Programmer's Manual.

3021 *** SYSTEM FATAL MESSAGE 3021, FILE *** NØT DEFINED IN FIST.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

3022 *** SYSTEM WARNING MESSAGE 3022, DATA SET ******** IS REQUIRED AS INPUT AND IS NØT ØUTPUT BY A PREVIØUS MØDULE IN THE CURRENT DMAP RØUTE.

Segment File Allocator (SFA) detected that an input data block to a future module has not been generated. If the future module requires that this data block exist, the module may terminate with a fatal error.

This message may occur (and most often does) when the Segment File Allocator has removed from its tables (due to a need for more room) previously purged data blocks. In this case no error or even a warning is implied.

3023 *** USER INFØRMATIØN MESSAGE 3023, B = ****, C = ****, R = ****.

Gives the upper bandwidth (B) and number of active columns (C) used in the symmetric decomposition.

3024 *** USER INFØRMATIØN MESSAGE 3024, THE BANDWIDTH ØF MATRIX **** EXCEEDS THE MAXIMUM BANDWIDTH. A MAXIMUM BANDWIDTH ØF **** WILL BE USED.

This message indicates that a matrix has scattered terms way off the diagonal (i.e., a large bandwidth). Instead of searching all combinations of B and C, the search is started at the maximum bandwidth.

3025 *** SYSTEM FATAL MESSAGE 3025, ILLEGAL INDEX IN ACTIVE RØW ØR CØLUMN CALCULATIØN IN ****.

Possible machine error. Rerun problem. If error persists, a code error exists in the decomposition routine.

3026 *** SYSTEM FATAL MESSAGE 3026, MATRIX **** EXCEEDS MAXIMUM ALLØWABLE SIZE FØR BANDWIDTH PLUS ACTIVE CØLUMNS. BMAX = ****, CMAX = ****.

Sufficient space was not reserved for the generation of the B vs. C vector. SDCØMP should be recompiled to increase BMAX and CMAX.

3027 *** USER INFØRMATIØN MESSAGE 3027, **** DECØMPØSITIØN TIME ESTIMATE IS ******** SECØNDS.

Gives the estimated time required for a decomposition in seconds and the type of matrix, i.e., complex, real (double or single precision), symmetric or unsymmetric.

3028 *** USER INFØRMATIØN MESSAGE 3028, B = ****, BBAR = ****, C = ****, CBAR = ****, R = ****.

Gives the upper bandwidth (B), lower bandwidth (BBAR), number of active columns (C), and active rows (CBAR) used in the unsymmetric decomposition.

3029 *** SYSTEM FATAL MESSAGE 3029, PHYSICAL END-ØF-FILE ENCØUNTERED ØN DATA SET **** (FILE ****).

Since logical End-Of-Files are used by GINØ, a physical End-Of-File indicates an attempt to read beyond valid data.

3030 *** USER WARNING MESSAGE 3030, ØFP UNABLE TØ PRØCESS DATA BLØCK. A TABLE PRINT ØF THE DATA BLØCK FØLLØWS.

3031 Same as message 3032.

3032 *** USER FATAL MESSAGE 3032, UNABLE TØ FIND SELECTED SET (****) IN TABLE (****) IN SUBRØUTINE (****).

A particular set used in the problem was not included in the data. Good examples are loads, initial conditions, or frequency sets. Include the required data or change the Case Control Deck to select data already in problem. Set zero (0) has a special meaning. A set selection was required, but none was made. For example, no METHØD was selected for an eigenvalue extraction problem.

This message can also indicate that a LØAD card has referenced another LØAD card, which is not permitted.

3033 *** USER FATAL MESSAGE 3033, SUBCASE ID **** IS REFERENCED ØN ØNE ØR MØRE RANDPS CARDS BUT IS NØT A CURRENT SUBCASE ID.

The RANDPS set selected can only reference subcase identification numbers included in the current loop. All subcases in which the direct input matrices or transfer functions do not change are run together. Either add a subcase with referenced identification number, change your RANDPS cards or change the identification numbers on your current subcases.

3034 *** USER WARNING MESSAGE 3034, ØRTHØGØNALITY CHECK FAILED, LARGEST TERM = **** EPSI = ****.

The off-diagonal terms of the modal mass matrix are larger than the user input criteria on the EIGB or EIGR bulk data card. The eigenvectors are not orthogonal to this extent. This nonorthogonality is especially important if a modal formulation is contemplated.

3035 *** USER INFØRMATIØN MESSAGE 3035, FØR LØAD ** EPSILØN SUB E=*****.

This is an informative message reflecting the accumulated round-off error of the static solution.

3036 *** SYSTEM FATAL MESSAGE 3036, DATA SET ******** IS REQUIRED AS INPUT BUT HAS NØT BEEN GENERATED ØR PURGED.

The above mentioned data set is not accounted for on the ØPTP checkpoint dictionary. The message indicates a failure of the File Name Table. As an interim measure the user can use the ALTER feature to execute the proper module to create the needed data set.

3037 *** SYSTEM FATAL MESSAGE 3037, JØB TERMINATED IN SUBRØUTINE ****.

This message designates the subroutine in which the program terminated. It should be preceeded by a user message which explains the cause of the termination. The module in which the program terminated can be found by examining the online time messages.

3038 *** SYSTEM FATAL MESSAGE 3038, DATA SET *** DØES NØT HAVE MULTIREEL CAPABILITY.

Computer hardware/software does not support multireel files.

3039 *** SYSTEM FATAL MESSAGE 3039, ENDSYS CANNØT FIND SAVE FILE.

File cannot be found to save and restore executive tables during link switching.

3040 *** SYSTEM FATAL MESSAGE 3040, ATTEMPT TØ WRITE DATA SET ********(FILE ***) WHEN IT IS AN INPUT FILE.

Input data blocks for a module (100 .LT. NAME .LT. 200) may be read only.

3041 *** USER WARNING MESSAGE 3041, EXTERNAL GRID PØINT *** DØES NØT EXIST ØR IS NØT A GEØMETRIC GRID PØINT. THE BASIC ØRIGIN WILL BE USED.

The reference grid point specified on the PARAM GRDPNT card for weight and balance calculations in GPWG cannot be used.

3042 *** USER WARNING MESSAGE 3042, INCØNSISTENT SCALAR MASSES HAVE BEEN USED. EPSILØN/DELTA = *****.

The GPWG has detected inconsistant scalar masses. Direct masses have been used. Skew inertia's will result. Examine your scalar masses and CØNM1 cards.

3043 *** USER FATAL MESSAGE 3043, UNCØNNECTED EXTRA PØINT (MØDAL CØØRDINATE=***) HAS BEEN DETECTED BY SUBRØUTINE ****.

Extra points must be connected via Direct Matrix Input (or Transfer Functions) in modal transient or frequency response.

3044 *** USER FATAL MESSAGE 3044, A PØINT ØN NØNLINEAR LØAD SET **** NØLIN **** IS NØT AN EXTRA PØINT. ØNLY EXTRA PØINTS MAY HAVE NØNLINEAR LØADS IN A MØDAL FØRMULATIØN.

Modal transient analysis (Rigid Format D-12) will support nonlinear loads only on extra points. Pick another nonlinear load set.

3045 *** USER WARNING MESSAGE 3045, INSUFFICIENT TIME TØ CØMPLETE THE REMAINING ** SØLUTIØN(S) IN MØDULE ***.

The time specified on the NASTRAN TIME card has expired in the named module. The module will be terminated. NASTRAN will continue running until the time on the job card expires. Restart to obtain print-out, complete solutions or rerun problem.

3046 *** USER FATAL MESSAGE 3046, YØUR SELECTED LØADING CØNDITIØN, INITIAL CØNDITIØN, AND NØNLINEAR FØRCES ARE NULL. A ZERØ SØLUTIØN WILL RESULT.

Transient solution must have one of the above nonzero.

3047 *** USER FATAL MESSAGE 3047, NØ MØDES WITHIN RANGE AND LMØDES=0. A MØDAL FØRMULATIØN CANNØT BE MADE.

The modes used for a modal formulation must be selected by a PARAM card. Set LFREQ, HFREQ or LMØDES to request modes.

3048 *** SYSTEM FATAL MESSAGE 3048, BUFFER CØNTRØL WØRD INCØRRECT FØR GINØ **** ØPERATIØN ØN DATA BLØCK ****.

The buffer control word has been destroyed outside of GINØ or an attempt to READ a file opened to WRITE or similar error has occurred.

3049 *** SYSTEM FATAL MESSAGE 3049, GINØ UNABLE TØ PØSITIØN DATA BLØCK **** CØRRECTLY DURING **** ØPERATIØN.

A block number read does not match the expected block number. The file has been repositioned outside the GINØ environment or a machine or operating system error has occurred.

3050 *** USER FATAL MESSAGE 3050, INSUFFICIENT TIME REMAINING FØR DECØMPØSITIØN, ****. TIME ESTIMATE IS **** SECONDS.

The time estimated for a decomposition exceeds the remaining time. Increase the time estimate for the run.

3051 *** USER FATAL MESSAGE 3051, INITIAL CØNDITIØN SET **** WAS SELECTED FØR A MØDAL TRANSIENT PRØBLEM. INITIAL CØNDITIØNS ARE NØT ALLØWED IN SUCH A PRØBLEM.

3052 *** USER WARNING MESSAGE 3052, A RANDØM REQUEST FØR CURVE TYPE - **** -, PØINT - **** CØMPØNENT - **** -, SPECIFIES TØØ LARGE A CØMPØNENT ID. THE LAST CØMPØNENT WILL BE USED.

3053 *** USER WARNING MESSAGE 3053, THE ACCURACY ØF EIGENVALUE **** IS IN DØUBT. GIVENS-QR FAILED TØ CØNVERGE IN **** ITERATIØNS.

Each eigenvalue is computed to the precision limits of each machine consistent with the maximum number of iterations allowed. A programming change would be required to increase the maximum iteration parameter.

3054 *** USER WARNING MESSAGE 3054, THE ACCURACY ØF EIGENVECTØR **** CØRRESPØNDING TØ THE EIGENVALUE **** IS IN DØUBT.

The eigenvector failed to converge in the allowable number of iterations. Particular attention should be given to the off-diagonal terms of the modal mass matrix (MI) to determine if this vector is orthogonal to the remaining vectors. These terms will be computed and checked if field 9 on the EIGR card contains a nonzero value. The message is expected in the case of close or multiple eigenvalues, even though the vectors are properly computed.

3055 *** USER FATAL MESSAGE 3055, AN ATTEMPT TØ MULTIPLY ØR MULTIPLY AND ADD NØN-CØNFØRMABLE MATRICES TØGETHER WAS MADE IN MØDULE ******.

The multiply/add subroutine requires conformable matrices. There are two possible equations

1. $[X] = [A][B] + [C]$

The number of columns of [A] must be equal to the number of rows of [B] and the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of rows of [A].

2. $[X] = [A]^T[B] + [C]$

The number of rows of [A] must be equal to the number of rows of [B]; the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of columns of [A].

3056 *** USER FATAL MESSAGE 3056, NØ MASS MATRIX IS PRESENT BUT MASS DATA IS REQUIRED.

An operation with the mass matrix is required, such as a gravity loading condition, but none was created. A typical cause is the omission of RHØ on the MAT1 card.

3057 *** USER FATAL MESSAGE 3057, MATRIX **** IS NØT PØSITIVE DEFINITE.

A Cholesky decomposition was attempted on the above matrix, but a diagonal term was negative or equal to zero, such that the decomposition failed.

3058 *** USER WARNING MESSAGE 3058, EPSILØN IS LARGER THAN **** FØR SUBCASE ****.

The error residual (either ε_ℓ or ε_ϕ)

$$\varepsilon = \frac{\{u\}^T \{\delta P\}}{\{P\}^T \{u\}} \quad \text{is larger than would be expected for}$$

a well conditioned problem. Near singularities may exist.

3059 *** USER FATAL MESSAGE 3059, SET IDENTIFIER **** DØES NØT EXIST. ERRØR DETECTED IN SUBRØUTINE ****.

When describing displacement matrices only those set identifier (such as M or G) listed in DMAP module MATGPR are legal set descriptors. Choose a set descriptor which is legal (and describes the matrices to be operated on).

3060 *** USER FATAL MESSAGE 3060, SUBRØUTINE ******** - ØPTIØN **** NØT IN APPRØVED LIST.

3061 *** USER INFØRMATIØN MESSAGE 3061, THE MEASURE ØF NØN-PLANARITY IS **** FØR ELEMENT NUMBER ********.

The measure of non-planarity for isoparametric quadrilateral membrane elements is the distance from actual grid points to mean plane divided by the average length of the diagonals. This message is issued only when the absolute value of this measure is greater than .01.

3062 *** SYSTEM FATAL MESSAGE 3062, HMAT MATERIAL RØUTINE CALLED IN A NØN-HEAT-TRANSFER PRØBLEM.

3063 *** SYSTEM WARNING MESSAGE 3063, INPUT FØRCES DATSDRHA BLØCK DØES NØT HAVE CØRRECT DATA.

3064 *** SYSTEM WARNING MESSAGE 3064, INCØNSISTENT HBDY DATA RECØRDS. ********** **********

3065 *** SYSTEM WARNING MESSAGE 3065, THERE IS NØ EST DATA FØR HBDY ELEMENT ID = **********.

3066 *** USER WARNING MESSAGE 3066, THERE IS NØ TLØAD1 ØR TLØAD2 DATA FØR LØAD-ID = **********.

3067 *** USER WARNING MESSAGE 3067, LØAD SET ID = ********** IS NØT PRESENT.

3068 *** SYSTEM WARNING MESSAGE 3068, UNRECØGNIZED CARD TYPE = ********** FØUND IN -SLT- DATA BLØCK.

3069 *** USER WARNING MESSAGE 3069, ØUTPUT DATA BLØCK FØR FØRCES IS PURGED.

3070 *** USER WARNING MESSAGE 3070, QGE IS REQUIRED BY THIS MØDULE AND IS PURGED. NØ ØUTPUT FILE HAS BEEN CREATED.

3071 *** SYSTEM WARNING MESSAGE 3071, EXTRA DATA IN RADLST RECØRD ØF MATPØØL DATA BLØCK IGNØRED.

3072 *** USER WARNING MESSAGE 3072, TØØ MANY MATRIX VALUES INPUT VIA RADMTX BULK DATA FØR CØLUMN ********. EXTRA VALUES IGNØRED AS MATRIX SIZE IS DETERMINED TØ BE ØF SIZE ******** FRØM RADLST CØUNT ØF ELEMENT ID-S.

3073 *** USER FATAL MESSAGE 3073, NØ -HBDY- ELEMENT SUMMARY DATA IS PRESENT FØR ELEMENT ID = ********, WHICH APPEARS ØN A -RADLST- BULK DATA CARD.

3074 *** USER FATAL MESSAGE 3074, CØLUMN ******** ØF THE Y MATRIX IS NULL.

3075 *** USER FATAL MESSAGE 3075, INTERMEDIATE MATRIX Y IS SINGULAR.

3076 *** SYSTEM FATAL MESSAGE 3076, GPTT DATA IS NØT IN SØRT BY INTERNAL ID.

3077 *** USER FATAL MESSAGE 3077, THERE IS NØ GRID PØINT TEMPERATURE DATA ØR DEFAULT TEMPERATURE DATA FØR SIL PØINT ******** AND PØSSIBLY ØTHER PØINTS.

3078 *** USER FATAL MESSAGE 3078, NØ GPTT DATA IS PRESENT FØR TEMPERATURE SET ********.

3079 *** USER FATAL MESSAGE 3079, THERE ARE NØ -HBDY- ELEMENTS PRESENT.

3080 *** USER FATAL MESSAGE 3080, INTEGER VALUES ØF EMISSIVITY ENCØUNTERED ********** ELEMENT ID = **********.

3081 *** SYSTEM FATAL MESSAGE 3081, INCØNSISTENT USET DATA DETECTED.

3082 *** USER WARNING MESSAGE 3082, M = **********, N = **********.

More than one n-set degree-of-freedom is associated with an m-set degree-of-freedom. The term associated with the m-n indices given in the message is ignored.

3083 *** USER FATAL MESSAGE 3083, UM PØSITIØN = **********, SIL = **********.

An m-set degree-of-freedom is not expressed in terms of an n-set degree-of-freedom.

3084 *** USER FATAL MESSAGE 3084, THERE IS NØ TEMPERATURE DATA FØR SIL NUMBER **********.

3085 *** USER FATAL MESSAGE 3085, THE PF LØAD VECTØR IS EITHER PURGED ØR NULL.

3086 *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER **.

1. Convergence achieved.
2. Iteration limit has been reached.
3. Diverging solution.
4. Insufficient time.

3087 *** USER FATAL MESSAGE 3087, TEMPERATURE SET ********** IS NØT PRESENT IN GPTT DATA BLØCK.

3088 *** USER FATAL MESSAGE 3088, ILLEGAL GEØMETRY FØR REVØLUTIØN ELEMENT ****.

3089 *** USER FATAL MESSAGE 3089, ILLEGAL GEØMETRY FØR TRIANGLE ELEMENT ****.

3090 *** USER FATAL MESSAGE 3090, ILLEGAL GEØMETRY FØR QUAD. ELEMENT ****.

3091 *** SYSTEM WARNING MESSAGE 3091, A TRAPRG ELEMENT = ************** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

3092 *** USER FATAL MESSAGE 3092, TRIRG ØR TRAPRG ELEMENT = ************** PØSSESSES ILLEGAL GEØMETRY.

3093 *** SYSTEM FATAL MESSAGE 3093, ELEMENT = ******** REASØN = ******.

1. Less than 2 points have been referenced.
2. Unable to locate SIL value.
3. Unrecognized form for element.
4. Illegal number of points for this form of the element.
5. Illegal number of points for this form of the element.

3094 *** SYSTEM FATAL MESSAGE 3094, SLT LØAD TYPE ********** IS NØT RECØGNIZED.

3095 *** USER WARNING MESSAGE 3095, ELEMENT TYPE ********* WITH ID = *********, AND APPEARING ØN EITHER A QVECT, QBDY1, QBDY2, ØR QVØL LØAD CARD HAS THE SAME ID AS AN ELEMENT ØF ANØTHER TYPE AND IS NØT BEING USED FØR LØADING.

3096 *** USER FATAL MESSAGE 3096, ELEMENT ID = ********** AS REFERENCED ØN A QVØL, QBDY1, QBDY2, ØR QVECT LØAD CARD CØULD NØT BE FØUND AMØNG ACCEPTABLE ELEMENTS FØR THAT LØAD TYPE.

3097 *** USER FATAL MESSAGE 3097, CØLUMN ****** IS SINGULAR. UNSYMMETRIC ******** DECØMP ABØRTED.

USER FATAL MESSAGE 3097, CØLUMN ****** IS SINGULAR. SYMMETRIC ********** DECØMP ABØRTED.

When a matrix being read in is singular (null column or for symmetric decomposition a zero diagonal) the internal column number and type of decomposition is identified. The message does not appear for special cases such as less than three columns or for proportional rows.

3098 *** USER FATAL MESSAGE 3098, QDMEM2 ELEMENT STIFFNESS RØUTINE DETECTS ILLEGAL GEØMETRY FØR ELEMENT ID = **********.

3099 *** USER FATAL MESSAGE 3099, ELEMENT STIFFNESS CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** IS IMPØSSIBLE DUE TØ SINGULARITY IN CØNSTRAINT EQUATIØN.

3100 *** USER WARNING MESSAGE 3100, ELEMENT THERMAL LØAD CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** FINDS ILLEGAL GEØMETRY THUS NØ LØADS ØUTPUT FØR ELEMENT-ID NØTED.

3101 *** USER WARNING MESSAGE 3101, SINGULARITY ØR BAD GEØMETRY FØR QDMEM2 ELEMENT ID = ********* STRESS ØR FØRCES WILL BE INCØRRECT.

3199 *** USER WARNING MESSAGE 3199, NØN-FATAL MESSAGES MAY HAVE BEEN LØST BY ATTEMPTING TØ QUEUE MØRE THAN ***** MESSAGES.

4000 *** USER WARNING MESSAGE 4000, ØNE SIDE ØF ELEMENT ******** CØNNECTING FØUR PØINTS IS NØT APPRØXIMATELY PLANAR.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers.

4001 *** USER FATAL MESSAGE 4001, ELEMENT ********** DØES NØT HAVE CØRRECT GEØMETRY.

4002 *** USER FATAL MESSAGE 4002, MØDULE SSG1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4003 *** USER FATAL MESSAGE 4003, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid WEDGE and HEXAi elements must not have Poissons Ratio equal to 0.5.

4004 *** USER FATAL MESSAGE 4004, MØDULE SMA1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4005 *** USER FATAL MESSAGE 4005, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid TETRA elements must not have Poissons Ratio equal to 0.5.

4010 *** USER FATAL MESSAGE 4010, TEMPP3 BULK DATA CARD WITH SETID = ******** AND ELEMENT ID = ******** DØES NØT HAVE ASCENDING VALUES SPECIFIED FØR Z.

4011 *** USER FATAL MESSAGE 4011, ELEMENT TEMPERATURE SET ******** CØNTAINS MULTIPLE TEMPERATURE DATA SPECIFIED FØR ELEMENT ID ********.

Temperature for element is specified on more than one bulk data card.

4012 *** USER FATAL MESSAGE 4012, THERE IS NØ ELEMENT, GRID PØINT, ØR DEFAULT TEMPERATURE DATA FØR TEMPERATURE SET ******** WITH RESPECT TØ ELEMENT ********.

4013 *** USER FATAL MESSAGE 4013, PROBLEM LIMITATION OF 66 TEMPERATURE SETS HAS BEEN EXCEEDED.

4014 *** SYSTEM FATAL MESSAGE 4014, RØUTINE EDTL DETECTS BAD DATA ØN TEMPERATURE DATA BLØCK FØR SET ID = ********.

Data block GPTT should be investigated.

4015 *** SYSTEM WARNING MESSAGE 4015, ELEMENT THERMAL AND DEFØRMATIØN LØADING NØT CØMPUTED FØR ILLEGAL ELEMENT TYPE ******** IN MØDULE SSG1.

Only certain elements have algorithms for enforced deformation or thermal loading. This element type will not produce a load. Check DEFØRM and TEMPP1, TEMPP2, TEMPP3, and TEMPRB bulk data cards.

4016 *** USER FATAL MESSAGE 4016, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4017 *** USER FATAL MESSAGE 4017, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4018 *** USER FATAL MESSAGE 4018, A SINGULAR MATERIAL MATRIX -D- FØR ELEMENT ******** HAS BEEN DETECTED BY RØUTINE SSGKHI WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The element bending load - curvature relation is at fault and cannot be inverted.

4019 *** SYSTEM FATAL MESSAGE 4019, SDR2E DETECTS INVALID TEMPERATURE DATA FØR ********.

Data block table GPTT should be investigated.

4020 *** SYSTEM FATAL MESSAGE 4020, TA1A HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4021 *** SYSTEM FATAL MESSAGE 4021, TA1B HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4022 *** USER FATAL MESSAGE 4022, TA1B FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4023 *** USER FATAL MESSAGE 4023, TA1A FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4024 *** USER FATAL MESSAGE 4024, NØ CYJØIN CARDS WERE SUPPLIED.

4025 *** USER FATAL MESSAGE 4025, NØ SIDE 1 DATA FØUND.

4026 *** USER FATAL MESSAGE 4026, TØØ MANY SIDE 1 CARDS.

4027 *** USER FATAL MESSAGE 4027, NUMBER ØF ENTRIES IN SIDE 1 NØT EQUAL TØ NUMBER IN SIDE 2.

4028 *** USER FATAL MESSAGE 4028, THE CØDE FØR GRID PØINT, ********** DØES NØT MATCH THE CØDE FØR GRID PØINT **********.

4029 *** USER FATAL MESSAGE 4029, GRID PØINT, ********** APPEARS IN BØTH SIDE LISTS.

4030 *** USER WARNING MESSAGE 4030, CØMPØNENT *** ØF GRID PØINTS, ********** AND ********** CANNØT BE CØNNECTED.

4031 *** USER FATAL MESSAGE 4031, INSUFFICIENT CØRE = **** TØ READ DATA ØN AXIF CARD.

4032 *** USER WARNING MESSAGE 4032, NØ CØMPØNENTS ØF GRID PØINTS, ********** AND ********** WERE CØNNECTED.

4033 *** USER FATAL MESSAGE 4033, CØØRDINATE SYSTEM ID = **** AS SPECIFIED ØN AXIF CARD IS NØT PRESENT AMØNG ANY ØF CØRD1C, CØRD1S, CØRD2C, ØR CØRD2S CARD TYPES.

Cylindrical type assumed for continuing data check.

4034 *** USER FATAL MESSAGE 4034, INSUFFICIENT CØRE = **** TØ HØLD GRIDB CARD IMAGES.

4035 *** USER FATAL MESSAGE 4035, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A BDYLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4036 *** USER FATAL MESSAGE 4036, INSUFFICIENT CØRE TØ BUILD BØUNDARY LIST TABLE.

4037 *** USER FATAL MESSAGE 4037, GRID PØINT ********** IS LISTED MØRE THAN ØNCE.

4038 *** USER FATAL MESSAGE 4038, RINGFL CARD HAS ID = **** WHICH HAS BEEN USED.

An identification number of a RINGFL card is not unique.

4039 *** USER FATAL MESSAGE 4039, NØ CØØRDINATE SYSTEM DEFINED FØR GRID PØINT **********.

4040 *** USER FATAL MESSAGE 4040, ID = **** APPEARS ØN A BDYLIST CARD, BUT NØ RINGFL CARD IS PRESENT WITH THE SAME ID.

4041 *** USER FATAL MESSAGE 4041, ID = **** IS ØUT ØF PERMISSABLE RANGE ØF 1 to 499999.

The identification number of a RINGFL is too large to be processed.

4042 *** USER FATAL MESSAGE 4042, CØØRDINATE SYSTEM IS CYLINDRICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X2 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4043 *** USER FATAL MESSAGE 4043, CØØRDINATE SYSTEM IS SPHERICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X3 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4044 *** USER FATAL MESSAGE 4044, RINGFL CARD ID = **** HAS SPECIFIED A ZERØ RADIAL LØCATIØN.

4045 *** USER FATAL MESSAGE 4045, THE BØUNDARY LIST ENTRY FØR ID = **** HAS A ZERØ CRØSS-SECTIØNAL LENGTH.

A hydroelastic boundary can not be defined between two RINGFL points having the same location. Check BDYLIST and RINGFL.

4047 *** USER FATAL MESSAGE 4047, INSUFFICIENT CØRE TØ HØLD RINGFL IMAGES.

4048 *** USER FATAL MESSAGE 4048, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A FSLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4049 *** USER FATAL MESSAGE 4049, INSUFFICIENT CØRE TØ BUILD FREE SURFACE LIST TABLE.

4050 *** USER FATAL MESSAGE 4050, FSLIST CARD HAS INSUFFICIENT IDF DATA, ØR FSLIST DATA MISSING.

A referenced RINGFL point doesn't exist or the FSLIST card is in error. At least two points must be defined.

4051 *** USER FATAL MESSAGE 4051, AN MPC CARD HAS A SET ID SPECIFIED = 102. SET 102 IS ILLEGAL WHEN FLUID DATA IS PRESENT

This set identification number is reserved for internal use in hydroelastic problems.

4052 *** USER FATAL MESSAGE 4052, IDF = **** ØN A FREEPT CARD DØES NØT APPEAR ØN ANY FSLIST CARD.

A referenced RINGFL point must also appear on a FSLIST card.

4053 *** USER FATAL MESSAGE 4053, INSUFFICIENT CØRE TØ PERFØRM ØPERATIØNS REQUIRED AS A RESULT ØF FREEPT ØR PRESPT DATA CARDS.

4054 *** USER FATAL MESSAGE 4054, SET ID = 102 MAY NOT BE USED FOR SPC CARDS WHEN USING THE HYDROELASTIC-FLUID ELEMENTS.

This set identification number is reserved for internal use in hydroelastic problems.

4055 *** USER FATAL MESSAGE 4055, SET ID = 102 MAY NØT BE USED FØR SPC CARDS WHEN USING THE HYDRØELASTIC-FLUID ELEMENTS.

This set identification number is reserved for internal use in hydroelastic problems.

4056 *** USER FATAL MESSAGE 4056, RECORD ID **** **** IS ØUT ØF SYNC ØN DATA BLØCK NUMBER **** AN IFP4 SYSTEM ERRØR.

The record identification numbers are the values of LØCATE record ID. The data block numbers are the GINØ file numbers. Error implies that IFP4 is possibly operating on the wrong data block. This system error should not occur. Message comes from IFP4B.

4057 *** USER FATAL MESSAGE 4057, GRIDB CARD WITH ID = **** HAS A REFERENCE IDF = **** WHICH DØES NØT APPEAR IN A BØUNDARY LIST.

4058 *** USER FATAL MESSAGE 4058, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = *** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4059 *** USER FATAL MESSAGE 4059, THE FLUID BULK MØDULUS HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = **** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4060 *** SYSTEM FATAL MESSAGE 4060, CØØRDINATE SYSTEM = **** CAN NØT BE FØUND IN CSTM DATA.

Data blocks MATPØØL or CSTM have been changed illegally.

4061 *** SYSTEM FATAL MESSAGE 4061, CØNNECTED FLUID PØINT ID = **** IS MISSING BGPDT DATA.

Data blocks MATPØØL or BGPDT have been changed illegally.

4062 *** USER FATAL MESSAGE 4062, DMIG BULK DATA CARD SPECIFIES DATA BLØCK **** WHICH ALSØ APPEARS ØN A DMIAX CARD.

One direct input matrix may not be specified by both types of bulk data cards.

4063 *** USER FATAL MESSAGE 4063, ILLEGAL VALUE **** FØR PARAMETER CTYPE.

4064 *** USER FATAL MESSAGE 4064, ILLEGAL VALUES ******** FØR PARAMETERS N, KMAX.

4065 *** USER FATAL MESSAGE 4065, ILLEGAL VALUE ******** FØR PARAMETER NLØAD.

4066 *** USER FATAL MESSAGE 4066, SECØND ØUTPUT DATA BLØCK MUST NØT BE PURGED.

4067 *** USER FATAL MESSAGE 4067, VIN HAS ******** CØLS, GCYC HAS ******** RØWS.

4081 *** USER FATAL MESSAGE 4081, AXSLØT DATA CARD IS NØT PRESENT ØR IS INCØRRECT.

Acoustic analysis data is present and this data card is necessary.

4082 *** USER FATAL MESSAGE 4082, INSUFFICIENT CØRE TO HØLD ALL GRIDS CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4083 *** USER FATAL MESSAGE 4083, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4084 *** USER FATAL MESSAGE 4084, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES BEING CREATED INTERNALLY DUE TØ GRIDS CARDS SPECIFYING AN IDF.

Executive Module IFP5 is creating GRIDF cards from GRIDS cards. Increase core size.

4085 *** USER FATAL MESSAGE 4085, INSUFFICIENT CØRE TØ CØNSTRUCT ENTIRE BØUNDARY TABLE FØR SLBDY DATA CARDS.

Executive Module IFP5 requires five words of core for each entry in the SLBDY cards.

4086 *** USER FATAL MESSAGE 4086, CELAS2 DATA CARD HAS ID = XXX WHICH IS GREATER THAN 10000000, AND 10000000 IS THE LIMIT FØR CELAS2 ID WITH ACØUSTIC ANALYSIS DATA CARDS PRESENT.

Executive Module IFP5 is generating CELAS2 images and a possible conflict of ID numbers exists.

4087 *** USER FATAL MESSAGE 4087, SLBDY ID = XXX DØES NØT APPEAR ØN ANY GRIDS DATA CARD.

The SLBDY data card has a point listed which does not exist in the data.

4088 *** USER FATAL MESSAGE 4088, ØNE ØR MØRE ØF THE FØLLØWING ID-S NØT EQUAL TØ -1 HAVE INCØRRECT ØR NØ GEØMETRY DATA. ID = XXX, ID = XXX, ID = XXX.

The listed GRIDS points may have a bad radius or a slot width greater than geometrically possible.

4089 *** USER FATAL MESSAGE 4089, RHØ AS SPECIFIED ØN SLBDY ØR AXSLØT DATA CARD IS 0.0 FØR ID = XXX.

A value of density is required to formulate the slot boundary matrix terms.

4090 *** USER FATAL MESSAGE 4090, ØNE ØF THE FØLLØWING NØN-ZERØ IDENTIFICATIØN NUMBERS APPEARS ØN SØME CØMBINATIØN GRID, GRIDS, ØR GRIDF BULK DATA CARDS. ID = XXX, ID = XXX, ID = XXX.

All GRID, SPØINT, EPØINT, GRIDS, and GRIDF data cards should have unique identification numbers.

4091 *** USER FATAL MESSAGE 4091, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER XXX.

The listed CSLØT3 or CSLØT4 element has its connected points defining zero area or its density equal to zero.

4100 *** SYSTEM FATAL MESSAGE 4100, ØUTPUT3 UNABLE TØ ØPEN DATA BLØCK ********.

4101 *** SYSTEM FATAL MESSAGE 4101, ØUTPUT3 UNABLE TØ FIND NAME FØR DATA BLØCK *******************.

4102 *** SYSTEM FATAL MESSAGE 4102, ØUTPUT3 EØF.

4103 *** USER INFØRMATIØN MESSAGE 4103, ØUTPUT3 HAS PUNCHED MATRIX DATA BLØCK ******** ØNTØ DMI CARDS.

4104 *** USER FATAL MESSAGE 4104, ATTEMPT TØ PUNCH MØRE THAN 9999 DMI CARDS FØR A SINGLE MATRIX.

4105 *** USER INFØRMATIØN MESSAGE 4105, DATA BLØCK ******** RETRIEVED FRØM USER TAPE **** NAME ØF DATA BLØCK WHEN PLACED ØN USER TAPE WAS ********.

4106 *** SYSTEM FATAL MESSAGE 4106, MØDULE INPUTT1 - SHØRT REC.

4107 *** SYSTEM FATAL MESSAGE 4107, SUBRØUTINE INPTT1 UNABLE TØ ØPEN NASTRAN FILE ****.

4108 *** SYSTEM FATAL MESSAGE 4108, SUBRØUTINE INPTT1 UNABLE TØ ØPEN ØUTPUT DATA BLØCK ****.

4109 *** SYSTEM FATAL MESSAGE 4109, UNEXPECTED EØF IN SUBRØUTINE INPTT1.

4110 *** SYSTEM FATAL MESSAGE 4110, UNEXPECTED EØR IN SUBRØUTINE INPTT1.

4111 *** USER FATAL MESSAGE 4111, MØDULE INPUTT1 IS UNABLE TØ SKIP FØRWARD ********** DATA BLØCKS ØN PERMANENT NASTRAN FILE **** NUMBER ØF DATA BLØCKS SKIPPED = *****.

4112 *** USER FATAL MESSAGE 4112, MØDULE INPUTT1 - ILLEGAL VALUE FØR SECØND PARAMETER = *******************.

4113 *** USER FATAL MESSAGE 4113, MØDULE INPUTT1 - ILLEGAL VALUE FØR FIRST PARAMETER = *******************.

4114 *** USER INFØRMATIØN MESSAGE 4114, DATA BLØCK ******** WRITTEN ØN NASTRAN FILE ****, TRL = ************.

4115 *** SYSTEM FATAL MESSAGE 4115, MØDULE ØUTPUT1 - SHØRT REC.

4116 *** SYSTEM FATAL MESSAGE 4116, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN INPUT DATA BLØCK *****.

4117 *** SYSTEM FATAL MESSAGE 4117, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN NASTRAN FILE ****.

4118 *** USER FATAL MESSAGE 4118, ***** MØDULE ØUTPUT1 IS UNABLE TØ SKIP FØRWARD ********** DATA BLØCKS ØN PERMANENT NASTRAN FILE ****. **** NUMBER ØF DATA BLØCKS SKIPPED = *****.

4119 *** USER FATAL MESSAGE 4119, MØDULE ØUTPUT1 - ILLEGAL VALUE FØR SECØND PARAMETER = *******************.

4120 *** USER FATAL MESSAGE 4120, MØDULE ØUTPUT1 - ILLEGAL VALUE FØR FIRST PARAMETER =

4121 *** USER FATAL MESSAGE 4121, ØNLY ØNE (1) AXIF CARD ALLØWED IN BULK DATA.

4122 *** USER FATAL MESSAGE 4122, AXIF CARD REQUIRED.

4123 *** USER FATAL MESSAGE 4123, ØNLY ØNE (1) FLSYM CARD ALLØWED IN BULK DATA.

4124 *** USER WARNING MESSAGE 4124, THE SPCADD ØR MPCADD UNIØN CØNSISTS ØF A SINGLE SET.

4125 *** USER FATAL MESSAGE 4125, MAXIMUM ALLØWABLE HARMØNIC ID IS 99. DATA CØNTAINS MAXIMUM = ****.

4126 *** USER FATAL MESSAGE 4126, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME, DMIAX ****.

4127 *** USER FATAL MESSAGE 4127, USER TAPE **** NØT SET UP.

4128 *** USER FATAL MESSAGE 4128, MØDULE ØUTPUT1 - END-ØF-FILE ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4129 *** USER FATAL MESSAGE 4129, MØDULE ØUTPUT1 - END-ØF-RECØRD ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4130 *** USER FATAL MESSAGE 4130, MØDULE ØUTPUT1 - ILLEGAL TAPE CØDE HEADER = *******************.

4131 *** USER WARNING MESSAGE 4131, USER TAPE ID CØDE - ******** - DØES NØT MATCH THIRD ØUTPUT1 DMAP PARAMETER - ********.

4132 *** USER FATAL MESSAGE 4132, MØDULE INPUTT1 - END-ØF-FILE ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4133 *** USER FATAL MESSAGE 4133, MØDULE INPUTT1 - END-ØF-RECØRD ENCØUNTERED WHILE ATTEMPTING TØ READ TAPE ID CØDE ØN USER TAPE ****.

4134 *** USER FATAL MESSAGE 4134, MØDULE INPUTT1 - ILLEGAL TAPE CØDE HEADER = *******************.

4135 *** USER WARNING MESSAGE 4135, USER TAPE ID CØDE - ******** DØES NØT MATCH THIRD INPUTT1 DMAP PARAMETER - ******** -

4136 *** USER FATAL MESSAGE 4136, USER TAPE ID CØDE - ******** - DØES NØT MATCH THIRD INPUTT1 DMAP PARAMETER - ******** -.

4137 *** USER WARNING MESSAGE 4137, ALL ØUTPUT DATA BLØCKS FØR INPUTT1 ARE PURGED.

4138 *** USER WARNING MESSAGE 4138, DATA BLØCK ******** (DATA BLØCK CØUNT = ***** HAS PREVIØUSLY BEEN RETRIVED FRØM USER TAPE **** AND WILL BE IGNØRED.

4139 *** USER INFØRMATIØN MESSAGE 4139, DATA BLØCK ******** RETRIVED FRØM USER TAPE **** (DATA BLØCK CØUNT = *****)

4140 *** USER WARNING MESSAGE 4140, SECØNDARY VERSION ØF DATA BLØCK HAS REPLACED EARLIER ØNE.

4141 *** USER WARNING MESSAGE 4141, ØNE ØR MØRE DATA BLØCKS NØT FØUND ØN USER TAPE.

4142 *** USER FATAL MESSAGE 4142, ØNE ØR MØRE DATA BLØCKS NØT FØUND ØN USER TAPE.

5000 *** USER FATAL MESSAGE 5000, NEG. ØR ZERØ RADIUS DETECTED FØR CFLUID2 ELEMENT. ELEMENT NØ. ****.

5001 *** USER FATAL MESSAGE 5001, NEG. ØR ZERØ RADIUS DETECTED FØR CFLUID3 ØR CFLUID4 ELEMENT. ELEMENT NØ. ****.

5002 *** USER FATAL MESSAGE 5002, INTERIØR ANGLE GREATER THAN ØR EQUAL TØ 180 DEGREES. CFLUID4 ELEMENT NØ. ****.

5011 *** USER FATAL MESSAGE 5011, FIRST PARAMETER ***** NE TRAILER RECØRD PARAMETER *****.

5012 *** USER FATAL MESSAGE 5012, ENTRY ***** ØF SIL TABLE INCØMPATIBLE WITH NEXT ENTRY.

7.1 NASTRAN DICTIONARY

This section contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms. The first column of the Dictionary contains the NASTRAN terms in alphabetical order. The second column contains a code indicating a general category for each term. The codes and categories, along with general references to the Programmer's Manual and User's Manual, are as follows:

Code	Category	General Reference
IA	Input - Executive Control	UM-2.2
IB	Input - Bulk Data	UM-2.4
IC	Input - Case Control	UM-2.3
EM	Executive Module	UM-5.3.4
FMH	Functional Module - Heat	PM-4
FMS	Functional Module - Structural	PM-4
FMM	Functional Module - Matrix Operation	UM-5.3.1
FMU	Functional Module - Utility	UM-5.3.2
FMX	Functional Module - User	UM-5.3.3
DBM	Data Block - Matrix	PM-2
DBT	Data Block - Table	PM-2
P	Parameter Name	UM-3
L	Rigid Format Label	UM-3
PH	Common Phrase or Term	
M	Miscellaneous	

The third column of the Dictionary contains a definition or description of the terms given in the first column. References to the User's Manual are indicated by UM-i and the Programmer's Manual by PM-i, where i is the section number of the manual. References to particular rigid formats are indicated by D-i where i is the displacement approach rigid format number.

A	P	Parameter value used to control utility module MATGPR print of A-set matrices.
ABFL	DBM	$[A_{b,f\ell}]$ - Hydroelastic boundary area factor matrix.
ABFLT	DBM	Transpose of $[A_{b,f\ell}]$
ACCE	IC	Abbreviated form of ACCELERATIØN.
ACCELERATIØN	IC	Output request for acceleration vector. (UM-2.3, 4.2)
Active Column	PH	Column containing at least one nonzero term outside the band.
ADD	FMM	Functional module to add two matrices together.
ADD	M	Parameter constant used in utility module PARAM.
ADD5	FMM	Functional module to add up to five matrices together.
ADUMi	IB	Defines attributes of dummy elements 1 through 9.
ALL	IC	Output request for all of a specified type of output.
ALLEDGE TICS	IC	Request tic marks on all edges of X-Y plot.
ALTER	IA	Alter statement for DMAP or rigid format.
ALWAYS	P	Parameter set to -1 by a PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
AND	M	Parameter constant used in executive module PARAM.
AØUT$	M	Indicates restart with solution set output request.
APP	IA	Control card which specifies approach (DISP or DMAP).
APPEND	M	File may be extended (see FILE).
ASET	IB	Analysis set coordinate definition card.
ASET1	IB	Analysis set coordinate definition card.
AUTØ	IC	Requests X-Y plot of autocorrelation function.
AUTØ	DBT	Autocorrelation function table.
AXES	IC	Defines orientation of object for structure plot.
AXIC	DBT	Generated by Input File Processor 3 (IFP3) for axisymmetric conical shell problems.
AXIC	IB	Axisymmetrical conical shell definition card. When this card is present, most other bulk data cards may not be used.
AXIF	IB	Controls the formulation of a hydroelastic problem.
AXISYM$	M	Indicates restart with conical shell or hydroelastic elements.
AXISYMMETRIC	IC	Selects boundary conditions for axisymmetric shell problems or specifies the existence of hydroelastic fluid harmonics.
AXSLØT	IB	Controls the formulation of acoustic analysis problems.

B	PH	Upper semiband of matrix
B2DD	DBM	$[B^2_{dd}]$ - Partition of direct input damping matrix.
B2PP	DBM	$[B^2_{pp}]$ - Direct input damping matrix for all physical points.
B2PP	IC	Selects direct input matrices - input on DMIG bulk data cards for use in Dynamics Rigid Formats (D-7 thru D-12).
B2PP$	M	Indicates restart with change in direct input damping matrices.
BAA	DBM	$[B_{aa}]$ - Partition of damping matrix
BALL EDGE TICS	IC	Request for all edge tic marks to be plotted on lower frame of an X-Y plot.
BAR	IC	Requests structure plot for all bar elements.
BARØR	IB	Bar oeientation default definition.
BBAR	PH	Lower semiband of matrix.
BDD	DBM	$[B_{dd}]$ - Damping matrix used in direct formulation of dynamics problems (D-7 thru D-9).
BDEBA	P	Parameter used to indicate equivalence of BDD and BAA.
BDPØØL	DBT	Hydroelastic boundary description table.
BDYLIST	IB	Structure-fluid hydroelastic boundary definition.
BEGIN	EM	The first DMAP statement is always BEGIN.
BEGIN BULK	IB	Control card which marks the end of the case control deck. Cards following this card are assumed to be bulk data cards.
BETA	P	Factor in integration algorithm in transient heat transfer analysis.
BFF	DBM	$[B_{ff}]$ - Partition of damping matrix.
BGG	DBM	$[B_{gg}]$ - Damping matrix generated by Structural Matrix Assembler.
BGPDT	DBT	Basic grid point definition table.
BHH	DBM	$[B_{hh}]$ - Partition of damping matrix.
BKL0	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BKL1	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BL	IC	Requests Benson Lehner plotter.
BLANK FRAMES	IC	Requests blank frames between structure plots (UM-4.1).
BLEFT TICS	IC	Request for left edge tic marks to be plotted on bottom frame of an X-Y plot.

BMG	FMS	Generates DMIG card images describing interconnection of fluid and structure.
BNN	DBM	$[B_{nn}]$ - Partition of damping matrix.
BØTH	IC	Bulk data echo option - Requests both unsorted and sorted printout of bulk data deck.
BPI	IC	Bits per inch - Plot tape density must be specified on control cards in addition to this data card. The required value will vary from one installation to another.
BQG	DBM	Single-point forces of constraint for a Buckling Analysis problem (D-5).
BRIGHT TICS	IC	Request for right edge tic marks to be plotted on bottom frame for X-Y plot.
BUCKLING	IA	Selects rigid format for buckling analysis.
BUCKLING	P	Constant parameter value used in functional module READ in the Buckling Analysis Rigid Format (D-5).
BUCKLING	P	Used in printing rigid format error messages for Buckling Analysis (D-5).
Bulk Data Deck	PH	The third of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the BEGIN BULK card and ends with the ENDDATA card, and contains the data of the mathematical model. The format of each bulk data card is fixed field, 8 or 16 columns for each value.

C	M	Used in parameter section of DMAP statement. Indicates that parameter is a constant.
C	PH	Symbol for active column in triangular decomposition ($\bar{C}$ used for active rows).
CALCØMP	IC	Request California Computer plotter.
CAMERA	IC	Selects one or both of the two cameras for the SC 4020 cathode ray tube electronic plotter. This information must usually also be given to the plotter operator on the run submittal slip which will vary from one installation to another. (UM-4)
CARDNØ	P	Parameter used to accumulate a count of all card output punched except the NASTRAN restart dictionary.
CASE	FMS	Extracts user request from CASECC for current loop in dynamics rigid formats (D-7 thru D-12).
Case Control Deck	PH	The second of the three data decks necessary to run a problem under the NASTRAN system. It contains cards which select particular data sets from the Bulk Data Deck, output request cards and titling information. Cards in this deck are free field.
CASECC	DBT	Case control data block.
CASEXX	DBT	Case control data block as modified by functional module CASE.
CAXIF2	IB	Acoustic core element connection definition card.
CAXIF3	IB	Acoustic triangular element connection definition card.
CAXIF4	IB	Acoustic quadrilateral element connection definition card.
CBAR	IB	Bar element connection definition card.
CCØNEAX	IB	Axisymmetrical conical shell element connection card.
CDAMP1	IB	Scalar damper connection definition card.
CDAMP2	IB	Scalar damper property and connection definition card.
CDAMP3	IB	Scalar damper connection definition card (connecting scalar points).
CDAMP4	IB	Scalar damper property and connection definition card (connecting scalar points).
CDUMi	IB	Defines definition card for dummy elements 1 through 9.
CEAD	FMS	Complex Eigenvalue Analysis - Displacement.
CEIG	P	Parameter used in SDR2 in Complex Eigenvalue Analysis (D-7 and D-10).
CEIGN	P	Parameter used in VDR in Complex Eigenvalue Analysis (D-7 and D-10).
CELAS1	IB	Scalar spring connection definition card.
CELAS2	IB	Scalar spring property and connection definition card.

CELAS3	IB	Scalar spring connection definition card (connecting scalar points).
CELAS4	IB	Scalar spring property and connecting definition card (connecting scalar points).
CEND	IA	The last card of the Executive Control Deck.
CFLUID2	IB	Fluid core element connection definition card.
CFLUID3	IB	Fluid triangular element connection definition card.
CFLUID4	IB	Fluid quadrilateral element connection definition card.
CHBDY	IB	Boundary element connection definition card for heat transfer analysis.
Checkpoint	PH	The process of writing selected data blocks onto the New Problem Tape for subsequent restarts.
CHEXA1	IB	Hexahedron element connection definition card - five tetrahedra.
CHEXA2	IB	Hexahedron element connection definition card - ten tetrahedra.
CHKPNT	EM	Checkpoint module.
CHKPNT	IA	Request for checkpoint execution.
CLAMA	DBT	Complex eigenvalue output table.
CLEAR	IC	Causes all parameter values used for X-Y plots to be reset to their default values except plotter and the titles (UM-4.2).
CMASS1	IB	Scalar mass connection definition card.
CMASS2	IB	Scalar mass property and connection definition card.
CMASS3	IB	Scalar mass connection definition card (connecting scalar points).
CMASS4	IB	Scalar mass property and connection definition card (connecting scalar points).
CMETHØD	IC	Complex eigenvalue analysis method selection.
CMETHØD$	M	Indicates restart with change in complex eigenvalue analysis method selection.
CMPLEV	P	Parameter used in GKAD to indicate complex eigenvalue problem.
Cold Start	PH	A NASTRAN problem initiated at its logical beginning. A cold start will never use an Old Problem Tape but it may create a New Problem Tape for subsequent restarts.
CØLØR	IC	Selects ink color for table plotters (UM-4.1).
CØND	EM	Conditional transfer.
CØNM1	IB	Structural mass element connection definition card.
CØNM2	IB	Structural mass element connection definition card.
CØNRØD	IB	Rod element property and connection definition card.

CØNRØD	IC	Requests structure plot for all CØNRØD elements.
CØRD1C	IB	Cylindrical coordinate system definition (by grid point ID).
CØRD1R	IB	Rectangular coordinate system definition (by grid point ID).
CØRD1S	IB	Spherical coordinate system definition (by grid point ID).
CØRD2C	IB	Cylindrical coordinate system definition (by coordinates).
CØRD2R	IB	Rectangular coordinate system definition (by coordinates).
CØRD2S	IB	Spherical coordinate system definition (by coordinates).
CØSINE	IC	Indicates cosine boundary conditions for conical shell problem.
CØUPMASS	P	Parameter used to request coupled mass.
CPBAR	P	Selects coupled mass option for BAR element.
CPHID	DBM	Complex Eigenvectors - solution set.
CPHIP	DBM	Complex Eigenvectors - physical set.
CPQDPLT	P	Selects coupled mass option for QDPLT element.
CPQUAD1	P	Selects coupled mass option for QUAD1 element.
CPQUAD2	P	Selects coupled mass option for QUAD2 element.
CPRØD	P	Selects coupled mass option for RØD and CØNRØD elements.
CPTRBSC	P	Selects coupled mass option for TRBSC element.
CPTRIA1	P	Selects coupled mass option for TRIA1 element.
CPTRIA2	P	Selects coupled mass option for TRIA2 element.
CPTRPLT	P	Selects coupled mass option for TRPLT element.
CPTUBE	P	Selects coupled mass option for TUBE element.
CQDMEM	IB	Quadrilateral membrane element connection definition card.
CQDMEM1	IB	Isoparametric quadrilateral membrane element connection definition card.
CQDMEM2	IB	Quadrilateral membrane element connection definition card.
CQDPLT	IB	Quadrilateral bending element connection definition card.
CQUAD1	IB	General Quadrilateral element connection definition card.
CQUAD2	IB	Homogeneous quadrilateral element connection definition card.
CRØD	IB	Rod element connection definition card.
CSHEAR	IB	Shear panel element connection definition card.
CSLØT3	IB	Triangular slot element connection definition card for acoustic analysis.

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CSLØT4	IB	Quadrilateral slot element connection definition card for acoustic analysis.
CSTM	DBT	Coordinate System Transformation Matrices.
CTETRA	IB	Tetrahedron element connection definition card.
CTØRDRG	IB	Toroidal ring element connection card.
CTRAPRG	IB	Trapezoidal ring element connection card.
CTRBSC	IB	Basic bending triangular element connection definition card.
CTRIA1	IB	General triangular element connection definition card.
CTRIA2	IB	Homogeneous triangular element connection definition card.
CTRIARG	IB	Triangular ring element connection card.
CTRMEM	IB	Triangular membrane element connection definition card.
CTRPLT	IB	Triangular bending element connection definition card.
CTUBE	IB	Tube element connection definition card.
CTWIST	IB	Twist panel element connection definition card.
CURVLINESYMBØL	IC	Request to connect points with lines and/or to use symbols for X-Y plots.
CVISC	IB	Viscous damper element connection definition card.
CWEDGE	IB	Wedge element connection definition card.

D	P	Parameter value used to control utility module MATGPR print of solution set matrices.
DAREA	IB	Dynamic load scale card.
Data Block	PH	Designates a set of data (matrix, table) occupying a file. A file is "allocated" to a data block and a data block is "assigned" to a file.
Data Pool File	PH	An executive file containing the ØSCAR and any data blocks pooled by the Executive Segment File Allocator (XSFA) module. The contents of this file are described within the data pool dictionary (DPL).
DD	IC	Requests Data Display plotter.
DDR	FMX	This module is reserved for user implementation.
DDR1	FMS	Dynamic Data Recovery - Phase 1.
DDR2	FMS	Dynamic Data Recovery - Phase 2.
Deck	PH	1. NASTRAN Data Deck 2. Executive Control Deck 3. Case Control Deck 4. Bulk Data Deck 5. Restart Deck
DECØMØPT	P	Controls type of arithmetic used in the decomposition for frequency-response problems.
DECØMP	FMM	To decompose a square matrix into upper and lower triangular factors.
Default	PH	Many NASTRAN data items have default values supplied by the system. For example, the default value for MAXLINES is 20000.
DEFØRM	IB	Enforced element deformation definition card.
DEFØRM	IC	Enforced element deformation set selection.
DEFØRM$	M	Indicates restart with change in enforced element deformation selection.
DEFØRMATIØN	IC	Indicates subcases to be used for deformed structure plots.
DELAY	IB	Dynamic load time delay card.
Delete	IB	Delete cards from Bulk Data Deck.
DELTAPG	DBM	Incremental load vector in Piecewise Linear Analysis Rigid Format (D-6).
DELTAQG	DBM	Incremental vector of single point constraint forces in the Piecewise Linear Analysis Rigid Format (D-6).
DELTAUGV	DBM	Incremental displacement vector in the Piecewise Linear Analysis Rigid Format (D-6).
DENSITY	IC	Density of lines for SC 4020 plotter.
DENSITY	IC	Plot tape density must be specified to plotter operator on run submittal form and will vary from one installation to another (UM-4.1).

DET	IB	Eigenvalue analysis method option - determinant (see EIGR, EIGB, EIGC).
DIFF	P	Parameter used in the Piecewise Linear Analysis Rigid Format (D-6).
DIFFERENTIAL STIFFNESS	IA	Selects rigid format for static analysis with differential stiffness.
DIFFSTIF	P	Parameter used in the PRTPARM module in the Differential Stiffness Rigid Format (D-4).
DIRCEAD	P	Used in printing rigid format error messages for direct complex eigenvalue analysis (D-7).
DIRECT	P	Parameter used to indicate direct formulation of dynamics problems (D-7 thru D-9).
DIRECT CØMPLEX EIGENVALUES	IA	Selects rigid format for direct complex eigenvalue analysis.
DIRECT FREQUENCY RESPONSE	IA	Selects rigid format for direct frequency and random response.
DIRECT TRANSIENT RESPONSE	IA	Selects rigid format for direct transient response.
DIRFRRD	P	Used in printing rigid format error messages for direct frequency response.
DIRTRD	P	Used in printing rigid format error messages for direct transient response (D-9).
DISP	IA	Displacement approach to structural analysis.
DISP	IC	Abbreviated form of DISPLACEMENT.
DISPLACEMENT	IC	Request for output of displacement vector or eigenvector. (UM-2.3, 4.2)
DIT	DBT	Direct Input Table.
DIV	P	Parameter constant used in utility module PARAM.
DLØAD	IB	Dynamics load assembly definition.
DLØAD	IC	Dynamic load set solution request.
DLØAD$	M	Indicates restart with change in dynamic load set request.
DLT	DBT	Dynamic Loads Table.
DM	DBM	[D] - Rigid body transformation matrix.
DMAP	IA	Approach option (Direct Matrix Abstraction Program).
DMAP Instruction	PH	A statement in the DMAP Language.
DMAP Language	PH	Data block-oriented language used by the NASTRAN Executive System to direct the sequence and flow of modules to be executed.

DMAP Loop	PH	A DMAP sequence to be repeated, initiated with a LABEL DMAP instruction and terminated by a REPT DMAP instruction.
DMAP Module	PH	A module called by means of a DMAP instruction.
DMAP Sequence	PH	A set of DMAP instructions.
DMI	IB	Direct Matrix Input (data block is defined and used by user).
DMIAX	IB	Direct Matrix Input - Axisymmetric, used in dynamic rigid formats (D-7 thru D-12).
DMIG	IB	Direct Matrix Input - used in dynamic rigid formats (D-7 thru D-12).
DPD	FMS	Dynamic Pool Distributor.

DPH	M	Data Pool Housekeeper - Executive routine.
DPHASE	IB	Dynamic load phase lead card.
DS0	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DS1	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DSCØ	IC	Abbreviated form of DSCØEFFICIENT.
DSCØ$	M	Indicates restart with change in differential stiffness load factors.
DSCØEFFICIENT	IC	Selects set of differential stiffness factors which have been input on DSFACT cards.
DSCØSET	P	Differential Stiffness coefficient set number. Used in the Differential Stiffness Rigid Format (D-4).
DSFACT	IB	Differential stiffness factor set definition card.
DSLØØP	P	Controls DMAP looping in the Differential Stiffness Rigid Format (D-4).
DSMG1	FMS	Differential Stiffness Matrix Generator - Phase 1.
DSMG2	FMS	Differential Stiffness Matrix Generator - Phase 2.
DTI	IB	Direct Table Input - means by which user may directly input any table data block.
DUMMØD1	FMX	This module is reserved for user implementation.
DUMMØD2	FMX	This module is reserved for user implementation.
DUMMØD3	FMX	This module is reserved for user implementation.
DUMMØD4	FMX	This module is reserved for user implementation.
Dummy Element	PH	Provision for user to insert additional finite element into the NASTRAN element library.
Dump	PH	Printed output of contents of all, or a portion, of main memory at some point in the problem solution.
DYNAMICS	DBT	Generated by the Input File Processor (IFP) for Real Eigenvalue, Buckling, or any of the Dynamics Rigid Formats (D-3, D-5 and D-7 thru D-12).

E	P	Parameter value used by MATGPR to print matrices associated with extra points.
EAI	IC	Requests EAI 3500 plotter.
ECHØ	IC	Ouput request statement for echo of bulk data.
ECPT	DBT	Element Connection and Properties Table.
ECPTNL	DBT	Nonlinear subset of the ECPT. This data block is used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNL1	DBT	Updated version of the ECPTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNLPG	P	Error flag for the Piecewise Linear Analysis Rigid Format (D-6). If all elements in a piecewise linear analysis problem are linear, this error flag is set and a DMAP exit occurs.
ECT	DBT	Element Connection Table.
EDT	DBT	Enforced Deformation Table - generated by Input File Processor.
EED	DBT	Eigenvalue Extraction Data table (D-3, D-5, D-7, D-10, D-11, D-12).
EIGB	IB	Real eigenvalue extraction data for buckling analysis (D-5).
EIGC	IB	Complex eigenvalue extraction data card (D-7 and D-10).
EIGP	IB	Complex eigenvalue pole definition card (D-7 and D-10).
EIGR	IB	Real eigenvalue extraction data for normal mode analysis (D-3, D-10 thru D-12).
ELEMENTS	IC	Used in element set definition for structure plot.
ELFØRCE	IC	Ouput request card for element forces. (UM-2.3, 4.2).
ELSETS	DBT	Element plot set connection tables.
ELSTRESS	IC	Request for output of element stresses.(UM-2.3, 4.2)
END	IA	END is the last statement in all DMAP sequences.
ENDALTER	IA	Last card of alter packet.
ENDDATA	IB	End of Bulk Data Deck.
EØF	PH	End-of-File.
EPØINT	IB	Extra point definition card - used in dynamics problems only.
EPSHT	P	Used in convergence tests for nonlinear heat transfer analysis.
EPSILØN SUB E (ε_e)	PH	Error ratio computed in SSG3. $\varepsilon_e = \varepsilon_\ell$ if the referenced load is $\{P_\ell\}$ and $\varepsilon_e = \varepsilon_o$ if the referenced load is $\{P_o\}$. See page 3.2-10 for mathematical definition of ε_o and ε_ℓ.
EPT	DBT	Element Property Table - output by Input File Processor.
EQDYN	DBT	Equivalence of internal and external indices - dynamics.

EQEXIN	DBT	Equivalence of internal and external indices.
EQUIV	EM	Equivalence data blocks.
Equivalence	PH	Data blocks are considered equivalenced when references to their equivalent names access the same physical data file.
ERRØR1	L	Label used when rigid format errors are detected.
ERRØR2	L	Label used when rigid format errors are detected.
ERRØR3	L	Label used when rigid format errors are detected.
ERRØR4	L	Label used when rigid format errors are detected.
ERRØR5	L	Label used when rigid format errors are detected.
ERRØR6	L	Label used when rigid format errors are detected.
EST	DBT	Element Summary Table.
ESTL	DBT	Element Summary Table for Linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL	DBT	Element Summary Table for Nonlinear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL1	DBT	Updated version of the ESTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
EXCEPT	IC	Forms exceptions to string of values in set declarations.
EXCLUDE	IC	Used in set definition for structure plots.
Executive	PH	1. Executive Control Deck 2. NASTRAN Executive System
Executive Control Deck	PH	The first of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the ID card and ends with the CEND card. Among other things, cards in this deck select the solution approach and rigid format to be used, limit the execution time, and control checkpointing and restart.
Executive System	PH	The Executive System initiates a NASTRAN problem solution via the Preface, allocates files to data blocks during problem solution, controls the sequence of the modules to be executed, and provides for problem restart capability.
EXIT	EM	Program termination DMAP statement.
External Sort	PH	Order of grid, scalar and extra points determined by the user's numerical order of point identification.
Extra Point	PH	A "point" which is defined on an EPØINT bulk data card. An extra point has no geometrical coordinates, defines only one degree of freedom of the model and is used only in dynamics solutions.

F	P	Parameter value used by MATGPR to print F-set matrices.
FBS	FMM	Forward and Backward Substitution.
FE	P	Parameter used by MATGPR to print out FE-set matrices.
FIAT	M	File Allocation Table. Core resident executive table where data block names, status of the data blocks (assigned to a file, purged, equivalenced, etc.) and trailer for the data blocks are stored.
FILE	IA	Term appearing on the checkpoint dictionary cards indicating the file number (internal) associated with a particular data block.
FILE	M	The FILE DMAP statement specifies data block characteristics such as TAPE, SAVE, and APPEND.
File	PH	Designates an auxiliary storage area or unit.
FIND	IC	Selects parameters for structure plot.
FINIS	L	Label used in all displacement rigid format DMAPs to terminate execution of DMAP.
Finite Element	PH	Idealized unit of a structural model that represents the distributed elastic properties of a structure.
FIST	M	File Status Table. Core resident executive table where internal file names and pointers to the FIAT, pertaining only to the module being executed, are stored.
FLAGS	IA	Term appearing on the checkpoint dictionary cards indicating the status of a data block (equivalenced or not).
FLSYM	IB	Structural symmetry definition card for use in hydroelastic problems.
FLUID	IC	Indicates hydroelastic harmonic degrees of freedom.
FMØDE	P	Mode number of first mode selected by user in modal dynamics formulations.
FØRCE	IB	Static load definition (vector).
FØRCE	IC	Request for output of element forces.
FØRCE1	IB	Static load definition (magnitude and two grid points).
FØRCE2	IB	Static load definition (magnitude and four grid points).
FØRCEAX	IB	Static load definition for conical shell problem.
FREEPT	IB	Defines point on a free surface of a fluid for output purposes.
FREQ	IB	Frequency list definition.
FREQ$	M	Indicates restart with change in frequencies to be solved.
FREQ1	IB	Frequency list definition (linear increments).
FREQ2	IB	Frequency list definition (logarithmic increments).

FREQRESP	P	Parameter used in SDR2 to indicate a frequency response problem.
FREQUENCY	IC	Selects the set of frequencies to be solved in frequency response problems.
FRL	DBT	Frequency Response List.
FRQSET	P	Used in FRRD to indicate user selected frequency set.
FRRD	FMS	Frequency and Random Response - Displacement approach.
FSLIST	IB	Defines a free surface of a fluid in a hydroelastic problem.
Functional Module	PH	An independent group of subroutines that perform a structural analysis function.

G	P	1. Parameter used by MATGPR to print G-set matrices. 2. Parameter used to input uniform structural damping coefficient (D-7 thru D-9).
GEI	DBT	General Element Input.
GENEL	IB	General element definition.
GEØM1	DBT	Geometric data input table - generated by the Input File Processor.
GEØM2	DBT	Connection input table - generated by the Input File Processor.
GEØM3	DBT	Static load and temperature input table - generated by the Input File Processor.
GEØM4	DBT	Displacement sets definition input table - generated by the Input File Processor.
GINØ	M	General input/output. GINØ is a collection of subroutines which is the input/output control system for NASTRAN.
GINØ Buffer	PH	Storage reserved in open core for each GINØ file opened. The size of the buffer is machine dependent.
GINØ File Number	PH	File number used internally in DMAP modules to access data blocks.
GIV	IB	Eigenvalue analysis method option - Givens (see EIGR).
GKAD	FMS	General [K] Assembler - Direct.
GKAM	FMS	General [K] Assembler - Modal.
GM	DBM	$[G_m]$ - multipoint constraint transformation matrix.
GMD	DBM	$[G_m^d]$ - mulitpoint constraint transformation matrix used in dynamic analysis.
GNFIAT	M	Generate FIAT. The preface routine which generates the initial FIAT.
GØ	DBM	$[G_o]$ - structural matrix partitioning transformation matrix.
GØD	DBM	$[G_o^d]$ - Structural matrix partitioning transformation matrix used in dynamic analysis.
GP1	FMS	Geometry Processor - part 1.
GP2	FMS	Geometry Processor - part 2.
GP3	FMS	Geometry Processor - part 3.
GP4	FMS	Geometry Processor - part 4.
GPCT	DBT	Grid Point Connection Table.
GPDT	DBT	Grid Point Definition Table.
GPI	M	General Problem Initialization (see XGPI).
GPL	DBT	Grid Point List.

GPLD	DBT	Grid Point List used in dynamic analysis.
GPSETS	DBT	Grid point plot sets.
GPSP	FMS	Grid Point Singularity Processor.
GPST	DBT	Grid Point Singularity Table.
GPTT	DBT	Grid Point Temperature Table.
GPWG	FMS	Grid Point Weight Generator.
GRAV	IB	Gravity vector definition card.
GRDPNT	P	Used in all displacement rigid formats to specify execution of the grid point weight generator (GPWG) by the user. A positive value references a grid point of the structural model. A value of zero indicates the origin of the basic coordinate system.
GRDSET	IB	Grid point default definition card.
GRID	IB	Grid point definition card.
Grid Point	PH	A point in Euclidean 3 dimensional space defined on a GRID bulk data card. A grid point defines 6 degrees of freedom, 3 translational and 3 rotational.
GRID PØINTS	IC	Used in set definition for structure plots.
GRIDB	IB	Grid point definition card for hydroelastic model.
GRIDF	IB	Grid point definition card for axisymmetric fluid cavity.
GRIDS	IB	Grid point definition card for slotted acoustic cavity.

HARMØNICS	IC	Controls number of harmonics output in axisymmetric shell problems and hydroelastic problems.
HB2DD	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HB2PP	DBM	$[B^2_{pp}]$ - Partition of heat capacity matrix.
HBAA	DBM	$[B_{aa}]$ - Partition of heat capacity matrix.
HBDD	DBM	$[B_{dd}]$ - Partition of heat capacity matrix.
HBFF	DBM	$[B_{ff}]$ - Partition of heat capacity matrix.
HBGG	DBM	$[B_{gg}]$ - Heat capacity matrix.
HBNN	DBM	$[B_{nn}]$ - Partition of heat capacity matrix.
HDLT	DBT	Dynamic loads table for heat transfer analysis.
Header record	PH	Initial record of a data block. Typically a header record contains only 2 BCD words, the alphanumeric name of the data block.

HEAT	IA	Selects heat transfer analysis on APProach card.
HFREQ	P	High frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
HK2DD	DBM	$[K^2_{dd}]$ - Partition of heat conductivity matrix.
HK2PP	DBM	$[K^2_{pp}]$ - Partition of heat conductivity matrix.
HKAA	DBM	$[K_{aa}]$ - Partition of heat conductivity matrix.
HKDD	DBM	$[K_{dd}]$ - Partition of heat conductivity matrix.
HKFF	DBM	$[K_{ff}]$ - Partition of heat conductivity matrix.
HKFS	DBM	$[K_{fs}]$ - Partition of heat conductivity matrix.
HKGG	DBM	$[K_{gg}]$ - Heat conductivity matrix, including estimated linear component of radiation.
HKGGX	DBM	$[K^x_{gg}]$ - Heat conductivity matrix.
HKNN	DBM	$[K_{nn}]$ - Partition of heat conductivity matrix.
HØEF1X	DBT	Heat flux output table for CHBDY elements.
HPDØ	DBM	$\{P^o_d\}$ - Partition of dynamic load vector.
HPDT	DBM	$\{P^t_d\}$ - Partition of dynamic load vector.
HPPØ	DBM	$\{P^o_p\}$ - Partition of dynamic load vector.
HPSØ	DBM	$\{P^o_s\}$ - Partition of dynamic load vector.
HQGE	DBM	$[Q_{ge}]$ - Element radiation flux matrix for heat transfer analysis.
HRAA	DBM	$[R_{aa}]$ - Partition of radiation matrix.
HRDD	DBM	$[R_{dd}]$ - Partition of radiation matrix.
HRFF	DBM	$[R_{ff}]$ - Partition of radiation matrix.
HRGG	DBM	$[R_{gg}]$ - Radiation matrix for heat transfer analysis.
HRNN	DBM	$[R_{nn}]$ - Partition of radiation matrix.
HSLT	DBT	Static heat flux table.
HTØL	DBT	List of output time steps for heat transfer.

IC	IC	Transient analysis initial condition set selection.
ID	IA	The first card of any data deck is the identification (ID) card. The two data items on this card are BCD values.
IFP	EM	Input File Processor. The preface module which processes the sorted Bulk Data Deck and outputs various data blocks depending on the card types present in the Bulk Data Deck.
IFP1	EM	Input File Processor 1. The preface module which processes the Case Control Deck and writes the CASECC, PCDB and XYCDB data blocks.
IFP3	EM	Input File Processor 3. The preface module which processes bulk data cards for a conical shell problem.
IFP4	EM	Input File Processor 4. The preface module which processes bulk data cards for a hydroelastic problem.
IMAG	IC	Output request for real and imaginary parts of some quantity such as displacement, load, single point force of constraint element force, or stress.
IMPL	P	Parameter constant used in executive module PARAM.
INCLUDE	IC	Used in set definition for structure plots.
INERTIA	P	Used in printing rigid format error messages for Static Analysis with Inertia Relief (D-2).
INERTIA RELIEF	IA	Selects rigid format for static analysis with inertia relief.
INPT	M	A reserved NASTRAN physical unit (Tape) which must be set up by the user when used.
INPUT	FMU	Generates most of bulk data for selected academic problems.
Input Data Block	PH	A data block input to a module. An input data block must have been previously output from some module and may not be written on.
Input Data Cards	PH	The card input data to the NASTRAN system are in 3 sets, the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck.
INPUTT1	FMU	Reads data blocks from GINØ-written user tapes.
INPUTT2	FMU	Reads data blocks from FØRTRAN-written user tapes.
INPUTT3	FMX	Dummy user input module.
INPUTT4	FMX	Dummy user input module.
Internal Sort	PH	Same order as external sort except when SEQGP or SEQEP bulk data cards are used to change the sequence.
INV	IB	Inverse power eigenvalue analysis option - specified on EIGR, EIGB or EIGC cards.
IRES	P	Causes printout of residual vectors in statics rigid formats when set nonnegative via a PARAM bulk data card. (D-1, D-2, D-4, D-5, D-6).

JUMP	EM	Unconditional transfer DMAP statement.
JUMPPLØT	P	Parameter used by structure plotter modules PLTSET and PLØT.
K2DD	DBM	$[K^2_{dd}]$ - Partition of direct input stiffness matrix.
K2DPP	DBM	$[K^{2d}_{pp}]$ - Direct input stiffness matrix for all physical points from bulk data deck.
K2PP	DBM	$[K^2_{pp}]$ - Direct input stiffness matrix for all physical points.
K2PP	IC	Direct input stiffness matrix selection.
K2PP$	M	Indicates restart with change in direct input stiffness matrices.
K2XPP	DBM	$[K^{2x}_{pp}]$ - Direct input stiffness matrix excluding hydroelastic boundary stiffness matrix.
K4AA	DBM	$[K^4_{aa}]$ - Partition of structural damping matrix.
K4FF	DBM	$[K^4_{ff}]$ - Partition of structural damping matrix.
K4GG	DBM	$[K^4_{gg}]$ - Structural damping matrix generated by Structural Matrix Assembler.
K4NN	DBM	$[K^4_{nn}]$ - Partition of structural damping matrix.
KAA	DBM	$[K_{aa}]$ - Partition of stiffness matrix.
KBFS	DBM	$[K^b_{fs}]$ - Partition of combination of elastic stifffness matrix and differential stiffness matrix.
KBFL	DBM	$[K_{b,f\ell}]$ - Hydroelastic boundary stiffness matrix.
KBLL	DBM	$[K^b_{\ell\ell}]$ - Combination of elastic stiffness and differential stiffness used in static analysis with differential stiffness.
KBSS	DBM	$[K^b_{ss}]$ - Partition of combination of stiffness matrix and differential stiffness matrix.
KDAA	DBM	$[K^d_{aa}]$ - Partition of differential stiffness matrix.
KDAAM	DBM	$-[K^d_{aa}]$ - Differential stiffness matrix used in formulation of buckling problems (D-5).
KDD	DBM	$[K_{dd}]$ - Stiffness matrix used in direct formulation of dynamics problems (D-7 thru D-9).
KDEK2	P	Parameter indicating equivalence of KDD and K2DD.
KDEKA	P	Parameter indicating equivalence of KDD and KAA.
KDFF	DBM	$[K^d_{ff}]$ - Partition of differential stiffness matrix.
KDFS	DBM	$[K^d_{fs}]$ - Partition of differential stiffness matrix.
KDGG	DBM	$[K^d_{gg}]$ - Differential stiffness matrix prepared by Differential Stiffness Matrix Generator
KDNN	DBM	$[K^d_{nn}]$ - Partition of differential stiffness matrix.

KDSS	DBM	$[K^d_{ss}]$ - Partition of differential stiffness matrix.
KFF	DBM	$[K_{ff}]$ - Partition of stiffness matrix.
KFS	DBM	$[K_{fs}]$ - Partition of stiffness matrix.
KGG	DBM	$[K_{gg}]$ - Stiffness matrix generated by Structural Matrix Assembler.
KGGL	DBM	$[K^{\ell}_{gg}]$ - Stiffness matrix for linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
KGGLPG	P	Purge flag for KGGL matrix. If set to -1, it implies that there are no linear elements in the structural model. (D-6).
KGGNL	DBM	$[K^{n\ell}_{gg}]$ - Stiffness matrix for the nonlinear elements. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGSUM	DBM	Sum of KGGNL and KGGL. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGX	DBM	$[K^x_{gg}]$ - Stiffness matrix excluding general elements.
KGGXL	DBM	$[K^{x\ell}_{gg}]$ - Stiffness matrix for linear elements (excluding general elements). Used in the Piecewise Linear Rigid Format only. (D-6).
KHH	DBM	$[K_{hh}]$ - Stiffness matrix used in modal formulation of dynamics problems (D-10 thru D-12).
KLL	DBM	$[K_{\ell\ell}]$ - Stiffness matrix used in solution of problems in static analysis (D-1, D-2, D-4, D-5, D-6).
KLR	DBM	$[K_{\ell r}]$ - Partition of stiffness matrix.
KNN	DBM	$[K_{nn}]$ - Partition of stiffness matrix.
KØØ	DBM	$[K_{oo}]$ - Partition of stiffness matrix.
KRR	DBM	$[K_{rr}]$ - Partition of stiffness matrix.
KSS	DBM	$[K_{ss}]$ - Partition of stiffness matrix.

L	P	Parameter value used by MATGPR to print L-set matrices.
LABEL	EM	DMAP location.
LABEL	IC	Defines third line of titles to be printed on each page of printer output. Also used on plots.
LABEL	IC	Requests identification of grid points and/or elements on structure plot.
LAMA	DBT	Real eigenvalues.
LBLi	L	A label used in displacement approach rigid formats where i represents one or more characters used to form unique labels.
LBLL	DBM	$[L^b_{\ell\ell}]$ - Lower triangular factor of $[K^b_{\ell\ell}]$.
LEFT TICS	IC	Request for tic marks to be plotted on left hand edge of frame for X-Y plots.
LFREQ	P	Low frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
LGPWG	L	Label used in conjunction with the Grid Point Weight Generator.
LINE	IC	Number of data lines printed per page of printer output. It should be set to 50 for 11 x 17 inch paper, and to 35 for 8 1/2 x 17 inch paper.
LLL	DBM	$[L_{\ell\ell}]$ - Lower triangular factor of $[K_{\ell\ell}]$.
LMØDES	P	Number of lowest modes for modal formulation of dynamics problems (D-10 thru D-12).
LØAD	IB	Static load combination definition.
LØAD	IC	Static load set selection.
LØAD$	M	Indicates restart with change in static load set request.
LØGARITHMIC	IC	Requests logarithmic scales for X-Y plots.
LØGPAPER	IC	Requests logarithmic paper for X-Y plots.
LØØ	DBM	$[L_{oo}]$ - Lower triangular factor of $[K_{oo}]$.
LØØP1$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPBGN	L	Signifies the beginning of the Piecewise Linear Analysis Rigid Format DMAP Loop. (D-6).
LØØPEND	L	Signifies the end of the Piecewise Linear Analysis Rigid Format DMAP loop. (D-6).
LØØP$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØWER TICS	IC	Request for tic marks to be plotted on bottom edge of frame for X-Y plots.
LUSET	P	Order of USET.
LUSETD	P	Order of USETD.

M	P	Parameter value used by MATGPR to print M-set matrices.
M2DD	DBM	$[M^2_{dd}]$ - Partition of direct input mass matrix.
M2DPP	DBM	$[M^{2d}_{pp}]$ - Direct input mass matrix for all physical points from Bulk Data Deck.
M2PP	DBM	$[M^2_{pp}]$ - Direct input mass matrix for all physical points.
M2PP	IC	Direct input mass matrix selection.
M2PP$	M	Indicates restart with change in direct input mass matrices.
MAA	DBM	$[M_{aa}]$ - Partition of mass matrix.
MASS	IB	Eigenvector normalization option - used on EIGR card.
MAT1	IB	Material definition card for isotropic material.
MAT2	IB	Material definition card for anisotropic material.
MAT3	IB	Material definition card for orthotropic material.
MAT4	IB	Thermal material definition card for isotropic material.
MAT5	IB	Thermal material definition card for anisotropic material.
MATGPR	FMU	Utility module for printing matrices.
MATPØØL	DBT	Grid point oriented direct input matrix data pool, output by Input File Processor and used by functional module MTRXIN.
MATPRN	FMU	Utility module for printing matrices.
MATPRT	FMU	Utility module for printing matrices.
Matrix Control Block	PH	A seven word array, the first word is a GINØ file number, and words 2 through 7 comprise a matrix trailer.
Matrix Data Block	PH	A data block is classified as a matrix if and only if it is generated by one of the NASTRAN matrix packing routines, PACK or BLDPK.
Matrix Decomposition	PH	A factorization of a matrix K so that K = LU where L is a unit lower triangular matrix and U is an upper triangular matrix.
MATS1	IB	Specifies table references for stress-dependent material properties.
MATT1	IB	Specifies table references for temperature-dependent isotropic material properties.
MATT2	IB	Specifies table references for temperature-dependent anisotropic material properties.
MATT3	IB	Specifies table references for temperature-dependent orthotropic material properties.
MATT4	IB	Specifies table references for temperature-dependent isotropic, thermal material properties.

MATT5	IB	Specifies table references for temperature-dependent, anisotropic, thermal material properties.
MAX	IB	Eigenvector normalization option - used on EIGR, EIGB and EIGC cards.
MAXIMUM DEFØRMATIØN	IC	Indicates scale for deformed structure plots.
MAXIT	P	Limits maximum number of iterations in nonlinear heat transfer analysis.
MAXLINES	IC	Maximum printer output line count - default value is 20000.
MCE1	FMS	Multipoint Constraint Eliminator - part 1.
MCE2	FMS	Multipoint Constraint Eliminator - part 2.
MDD	DBM	$[M_{dd}]$ - Mass matrix used in direct formulation of dynamics problems (D-7 thru D-9).
MDEMA	P	Parameter indicating equivalence of MDD and MAA.
MDLCEAD	P	Used in printing rigid format error messages for modal complex eigenvalue analysis (D-10).
MDLFRRD	P	Used in printing rigid format error messages for modal frequency response (D-11).
MDLTRD	P	Used in printing rigid format error messages for modal transient response (D-12).
MERGE	FMM	Matrix merge functional module.
METHØD	IC	Selects method for real eigenvalue analysis.
METHØD$	M	Indicates restart with change in eigenvalue extraction procedures.
MFF	DBM	$[M_{ff}]$ - Partition of mass matrix.
MGG	DBM	$[M_{gg}]$ - Mass matrix generated by Structural Matrix Assembler.
MHH	DBM	$[M_{hh}]$ - Mass matrix used in modal formulation of dynamics problems (D-10 thru D-12).
MI	DBM	$[m]$ - Modal mass matrix.
MLL	DBM	$[M_{\ell\ell}]$ - Partition of mass matrix.
MLR	DBM	$[M_{\ell r}]$ - Partition of mass matrix.
MNN	DBM	$[M_{nn}]$ - Partition of mass matrix.
MØA	DBM	$[\bar{M}_{oa}]$ - Partition of mass matrix.
MØDA	FMX	This module is reserved for user implementation.
MØDACC	P	Requests mode acceleration data recovery.
MØDAL	IC	Requests structure plots of mode shapes.
MØDAL	P	Indicates modal as opposed to direct formulation of dynamics problems. (D-10 thru D-12).

MØDAL CØMPLEX EIGENVALUES	IA	Selects rigid format for modal complex eigenvalue analysis.
MØDAL FREQUENCY RESPØNSE	IA	Selects rigid format for modal frequency and random response.
MØDAL TRANSIENT RESPØNSE	IA	Selects rigid format for modal transient response.
MØDB	FMX	This module is reserved for user implementation.
MØDC	FMX	This module is reserved for user implementation.
MØDEL	IC	Indicates model number of structure plotter.
MØDES	IA	Selects rigid format for normal mode analysis.
MØDES	IC	Duplicates output requests for eigenvalue problems.
MØDES	P	Used in printing rigid format error messages for normal modes analysis (D-3).

Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution by changing the rigid format and/or selected input data.
Module	PH	A logical group of subroutines which performs a defined function.
MØMAX	IB	Conical shell moment definition card.
MØMENT	IB	Static moment load definition (vector).
MØMENT1	IB	Static moment load definition (magnitude and two grid points).
MØMENT2	IB	Static moment load definition (magnitude and four grid points).
MØØ	DBM	$[M_{oo}]$ - Partition of mass matrix.
MPC	IB	Multipoint constraint definition.
MPC	IC	Multipoint constraint set request.
MPC$	M	Indicates restart with change in multipoint constraints.
MPCADD	IB	Multipoint constraint set definition.
MPCAX	IB	Conical shell multipoint constraint definition.
MPCF1	P	No multipoint constraints.
MPCF2	P	No change in multipoint constraints for loop.
MPL	PH	Module properties list. The MPL defines each DMAP module's name, the number of input, output and scratch files required and the parameter list. It is used by the preface module XGPI to generate the ØSCAR.
MPT	DBT	Material Properties Table - output by Input File Processor.
MPY	M	Parameter constant used in executive module PARAM.
MPYAD	FMM	Performs multiply-add matrix operation.
MR	DBM	$[m_r]$ - Rigid body mass matrix.
MRR	DBM	$[M_{rr}]$- Partition of mass matrix.
MTRXIN	FMS	Selects direct input matrices for current loop in dynamics problems (D-7 thru D-12).
MX	IC	Indicates negative x-axis direction for structure plot.
MY	IC	Indicates negative y-axis direction for structure plot.
MZ	IC	Indicates negative z-axis direction for structure plot.

N	M	Used in parameter section of DMAP statement. Indicates that parameter may not be given an initial value with a PARAM bulk data card.
N	P	Parameter value used by MATGPR to print N-set matrices.
NASTPLT	IC	Requests NASTRAN general purpose plotter.
NASTRAN	M	Acronym for NAsa STRuctural ANalysis program.
NASTRAN Data Deck	PH	The composite deck consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. This deck, when preceeded by any necessary operating system control cards, constitutes the complete card input for a NASTRAN run (PM-5).
NE	P	Parameter value used by MATGPR to print out NE-set matrices.
NEIGV	P	Number of real eigenvalues found.
NEVER	P	Set to +1 by a DMAP PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
New Problem Tape	PH	See Problem Tape.
NLFT	DBT	Nonlinear function table.
NLLØAD	IC	Requests nonlinear load output for transient problems.
NØ	IA	Option used on CHKPNT card, indicates that no checkpoint is desired.
NØA	P	Indicates no constraints applied to structural model.
NØABFL	P	No fluid-structure interface in a hydroelastic problem.
NØB2PP	P	No direct input damping matrix.
NØBGG	P	No viscous damping matrix (D-7 thru D-9).
NØCSTM	P	No Coordinate System Transformation Matrices.
NØD	P	No output request that is limited to independent degrees of freedom.
NØDLT	P	No Dynamic Loads Table.
NØEED	P	No Eigenvalue Extraction Data
NØELMT	P	No elements are defined.
NØFL	P	No fluid-structure interface and no fluid gravity in a hydroelastic problem.
NØFRL	P	No Frequency Response List.
NØGENEL	P	No general elements.
NØGPDT	P	No Grid Point Definition Table.
NØGRAV	P	No gravity loads.
NØK2DPP	P	No direct input stiffness matrix from Bulk Data Deck.
NØK2PP	P	No direct input stiffness matrices.

NØK4GG	P	No structural damping matrix.
NØKBFL	P	No fluid gravity or structural interface in a hydroelastic problem.
NØL	P	No independent degrees of freedom.
NØLIN1	IB	Nonlinear transient dynamic load set definition card.
NØLIN2	IB	Nonlinear transient dynamic load set definition card.
NØLIN3	IB	Nonlinear transient dynamic load set definition card.
NØLIN4	IB	Nonlinear transient dynamic load set definition card.
NØLØØP$	M	Indicates restart of problem without DMAP loop. (PM-4.3.7.1).
NØM2DPP	P	No direct input mass matrix from Bulk Data Deck.
NØM2PP	P	No direct input mass matrices.
NØMGG	P	If functional module SMA2 generates a zero mass matrix, NØMGG is set to -1. Otherwise, it is set to +1.
NØMØD	P	Mode acceleration data recovery not requested.
NØNCUP	P	Indicates diagonal MHH, BHH, and KHH allowing uncoupled solution in TRD and FRRD.
NØNE	IC	Override for output and bulk data deck echo requests.
NØNLFT	P	No nonlinear function table.
NØNLINEAR	IC	Selects nonlinear load for transient problems.
NØNLSTR	P	No stress output request for nonlinear elements (D-6).
NØP	M	Parameter constant used in executive module PARAM.
NØP	P	No output request involving dependent degrees of freedom or stresses.
NØPSDL	P	No Power Spectral Density List.
NØRMAL MØDES	IA	Selects rigid format for normal mode analysis.
NØSET	P	No dependent coordinates.
NØSIMP	P	No structural elements are defined.
NØSØRT2	P	No request for output sorted by point number or element number.
NØSR	P	No single-point constraints or free body supports.
NØT	M	Parameter constant used in utility module PARAM.
NØTFL	P	No Transfer Function List.
NØTRL	P	No Transient Response List.
NØUE	P	No extra points introduced for dynamic analysis.
NPLALIM	P	Set by module PLA1 as the Piecewise Linear Analysis Rigid Format DMAP loop counter. (D-6)

NPTP	M	New Problem Tape - a reserved NASTRAN physical unit (TAPE) which must be set up by the user when used.
NSIL	P	Order of SIL table.
NSKIP	P	Locate current boundary conditions in Case Control.
NUMF	M	New User Master File - used only when operating NASTRAN as a user master file editor. (See UMFEDIT). A reserved NASTRAN physical unit (tape) which must be set up by the user when used.
NVECTS	P	Number of eigenvectors found.

Ø	P	Parameter value used by MATGPR to print Ø-set matrices.
ØBEF1	DBT	Element force output table (D-5).
ØBES1	DBT	Element stress output table (D-5).
ØBQG1	DBT	Forces of single point constraint output table (D-5).
ØCEIGS	DBT	Complex eigenvalue summary table (D-7, D-10).
ØCPHIP	DBT	Complex eigenvector output table (D-7, D-10).
ØEF1	DBT	Element force output table (D-1, D-2, D-4, D-5, D-6).
ØEF2	DBT	Element force output table - SØRT2 (D-9, D-12).
ØEFB1	DBT	Element force output table (D-4).
ØEFC1	DBT	Element force output table - complex (D-7, D-8, D-10, D-11).
ØEFC2	DBT	Element force output table - complex - SØRT2 (D-8, D-11).
ØEIGS	DBT	Real Eigenvalue summary output table (D-3, D-5).
ØES1	DBT	Element stress output table (D-1, D-2, D-4, D-5, D-6).
ØES2	DBT	Element stress output table - SØRT2 (D-9, D-12).
ØESB1	DBT	Element stress output table (D-4).
ØESC1	DBT	Element stress output table - complex (D-7, D-8, D-10, D-11).
ØESC2	DBT	Element stress output table - complex - SØRT2 (D-8, D-11).
ØFP	FMS	Output File Processor.
ØFREQUENCY	IC	Selects from the solution set of frequencies a subset for output requests.
ØGPST	DBT	Grid point singularity output table.
ØGPWG	DBT	Grid point weight generator output table.
Old Problem Tape	PH	See Problem Tape.
ØLØAD	IC	Request for output of external load vector.
ØMIT	IB	Omitted coordinate definition card.
ØMIT	P	Indicates no omitted coordinates.
ØMIT1	IB	Omitted coordinate definition card.
ØMITAX	IB	Omitted coordinate definition card for conical shell problems.
ØNLES	DBT	Output table for nonlinear element stresses (D-6).
Open Core	PH	A contiguous block of working storage defined by a labeled common block, whose length is a variable determined by the NASTRAN executive routine CØRSZ.
ØPG1	DBT	Static load output table (D-1, D-2, D-4, D-5, D-6).

ØPHID	DBT	Output table for complex eigenvectors - solution set (D-7).
ØPHIG	DBT	Eigenvector output table (D-3, D-5).
ØPHIH	DBT	Output table for complex eigenvectors - solution set (D-10).
ØPNL1	DBT	Output table for nonlinear loads - solution set, SØRT1 (D-9, D-12).
ØPNL2	DBT	Output table for nonlinear loads - solution set, SØRT2 (D-9, D-12).
ØPP1	DBT	Dynamic load output table (D-9, D-12).
ØPP2	DBT	Dynamic load output table - SØRT2 (D-9, D-12).
ØPPC1	DBT	Dynamic load output table - SØRT1, complex (D-8, D-11).
ØPPC2	DBT	Dynamic load output table - SØRT2, complex (D-8, D-11).
ØPTP	M	Old Problem Tape - a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
ØQBG1	DBT	Forces of single-point constraint output table (D-4).
ØQG1	DBT	Single-point constraint force output table (D-1, D-2, D-4, D-5, D-6).
ØQP1	DBT	Single-point constraint force output table SØRT1 (D-9, D-12).
ØQP2	DBT	Single-point constraint force output table SØRT2 (D-9, D-12).
ØQPC1	DBT	Single-point constraint force output table - complex, SØRT1 (D-7, D-8, D-10, D-11).
ØQPC2	DBT	Single-point constraint force output table - complex, SØRT2 (D-7, D-8, D-10, D-11).
ØR	M	Parameter constant used in executive module PARAM.
ØRIGIN	IC	Locates origin for structure plot.
ØRTHØGRAPHIC	IC	Specifies orthographic projection for structure plot.
ØSCAR	PH	Operation sequence control array. Executive table residing on the Data Pool File which contains the sequence of operations to be executed for a problem solution. The ØSCAR is an expansion of a DMAP sequence, either input by the user or extracted from a rigid format, in internal format.
ØUBGV1	DBT	Displacement vector output table (D-4).
ØUDV1	DBT	Displacement vector output table - solution set, SØRT1 (D-9).
ØUDV2	DBT	Displacement vector output table - solution set, SØRT2 (D-9).
ØUDVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-8, D-11).

ØUDVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-8, D-11).
ØUGV1	DBT	Displacement output table (D-1, D-2, D-4, D-5, D-6).
ØUHV1	DBT	Displacement vector output table - solution set, SØRT1 (D-12).
ØUHV2	DBT	Displacement vector output table - solution set, SØRT2 (D-12).
ØUHVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-11).
ØUHVC2	DBT	Displacement vector output table - solution set, SØRT2 complex (D-11).
ØUPV1	DBT	Displacement vector output table - SØRT1 (D-9, D-12).
ØUPV2	DBT	Displacement vector output table - SØRT2 (D-9, D-12).
ØUPVC1	DBT	Displacement vector output table - complex, SØRT1 (D-8, D-11).
ØUPVC2	DBT	Displacement vector output table - complex, SØRT2 (D-8, D-11).
ØUTPUT	FMX	This module is reserved for user implementation.
ØUTPUT	IC	Marks beginning of printer output request packet - optional.
Output Data Block	PH	A data block output from a module. A data block may be output from one and only one module. Having been output, it may be used as an input data block as many times as necessary.
ØUTPUT1	FMU	Writes data blocks on GINØ-written user tapes.
ØUTPUT2	FMU	Writes data blocks on FØRTRAN-written user tapes.
ØUTPUT3	FMU	Punches matrices on DMI cards.
ØUTPUT4	FMX	Dummy user output module.
ØUTPUT(PLØT)	IC	Marks beginning of output request packet for structure plots.
ØUTPUT(XYØUT)	IC	Marks beginning of output request packet for X-Y plots.
ØUTPUT(XYPLØT)	IC	Marks beginning of output request packet for X-Y plots.

P	P	Parameter value used in MATGPR to print P-set matrices.
Packed Format	PH	A matrix is said to be in packed format if only the nonzero elements of the matrix are written.
PAPER SIZE	IC	Selects paper size for structure plots using table plotters.
PARAM	FMU	Performs specified operations on DMAP parameters.
PARAM	IB	Parameter definition card.
Parameter	PH	A FØRTRAN variable communicated to a DMAP module by the NASTRAN Executive System through blank common. A parameter's position in the DMAP calling sequence to a module corresponds to the position of the parameter in blank common at module execution time.
PARAML	FMU	Selects parameters from a user input matrix or table.
PARAMR	FMU	Performs specified operations on real or complex parameters.
PARTN	FMM	Matrix partitioning functional module.
PBAR	IB	Bar property definition card.
PBL	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PBS	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PCDB	DBT	Plot control data block (table for use with structure plotter functional module PLTSET).
PCØNEAX	IB	Conical shell element property definition card.
PDAMP	IB	Scalar damper property definition card.
PDF	DBM	Dynamic load matrix for frequency analysis.
PDT	DBM	Linear dynamic load matrix for transient analysis.
PDUMi	IB	Property definition card for dummy elements 1 through 9.
PELAS	IB	Scalar elastic property definition card.
PEN	IC	Selects pen size for structure plots using table plotters.
PENSIZE	IC	Selects pen size for X-Y plots using table plotters.
PERSPECTIVE	IC	Specifies perspective projection for structure plots.
PFILE	P	Parameter used by PLØT module.
PG	DBM	Incremental load vector used in Piecewise Linear Analysis (D-6).
PG	DBM	Statics load vector generated by SSG1.
PG1	DBM	Static load vector for Piecewise Linear Analysis (D-6).
PGG	DBM	Appended static load vector (D-1, D-2).

PGV1	DBM	Matrix of successive sums of incremental load vectors used only in Piecewise Linear Analysis Rigid Format (D-6).
PHASE	IC	Requests magnitude and phase form of complex quantities.
PHBDY	IB	Boundary element property definition card for heat transfer analysis.
PHIA	DBM	$[\phi_a]$ - Real eigenvectors - solution set.
PHID	DBM	$[\phi_d]$ - Complex eigenvectors - solution set, direct formulation.
PHIDH	DBM	$[\phi_{dh}]$ - Transformation matrix between modal and physical coordinates.

PHIG	DBM	$[\phi_g]$ - Real eigenvectors.
PHIH	DBM	$[\phi_h]$ - Complex eigenvectors - solution set, modal formulation.
Physical Points	PH	Grid points and extra scalar points introduced for dynamic analysis.
PIECEWISE LINEAR	IA	Selects rigid format for piecewise linear analysis.
Pivot Point	PH	The first word of each record of the GPCT and ECPT data blocks is called the pivot point.
PL	DBM	$\{P_\ell\}$ - Partition of load vector.
PLA	P	Used in printing rigid format error messages for Piecewise Linear Analysis (D-6).
PLA1	FMS	Piecewise Linear Analysis - phase 1.
PLA2	FMS	Piecewise Linear Analysis - phase 2.
PLA3	FMS	Piecewise Linear Analysis - phase 3.
PLA4	FMS	Piecewise Linear Analysis - phase 4.
PLACØUNT	P	Loop counter in Piecewise Linear Analysis (D-6).
PLALBL2A	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL3	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL4	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLCØEFFICIENT	IC	Selects the coefficient set for Piecewise Linear Analysis problems.
PLFACT	IB	Piecewise Linear Analysis factor definition card.
PLI	DBM	$\{P^i_\ell\}$ - Partition of inertia relief load vector.
PLØAD	IB	Pressure load definition (D-1, D-2, D-4, D-5, D-6).
PLØAD2	IB	Element pressure loading for two-dimensional elements (D-1, D-2, D-4, D-5, D-6).
PLØT	FMS	Structure plot generator.
PLØT	IC	Execution card for structure plotter.
PLØT$	M	Indicates restart with a structure plot request.
Plot Tapes	PH	Magnetic tapes containing NASTRAN generated data to drive offline plotters. PLT1 is the name of the BCD plot tape, used by the EAI 3500, and PLT2 is the name of binary plot tape, used by the SC-4020.
PLØTEL	IB	Plot element definition card used to define convenient reference lines in structure plots.
PLØTTER	IC	Used to select one of several available plotters for structure plotter.

PLØTX1	DBT	Messages from plot module concerning action taken by the structure plotter in processing undeformed structure plots.
PLØTX2	DBT	Messages from plot module concerning action taken by the structure plotter in processing deformed structure plots.
PLSETNØ	P	Set number on a PLFACT bulk data card chosen by the user in his case control deck. Used only in Piecewise Linear Analysis (D-6).
PLT1	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLT2	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLTFLG	P	Parameter used by PLØT module.
PLTPAR	DBT	Plot control table.
PLTSET	FMS	Plot set definition processor.
PLTSETX	DBT	Error messages for plot sets.
PLTTRAN	FMS	Prepares data blocks for acoustic analysis plots.
PLTTRAN	FMS	Transforms grid point definition tables for scalar points into a format for plotting.
PMASS	IB	Scalar mass property definition card.
PNLD	DBM	$\{P_d^n\}$ - Nonlinear loads in direct transient problem.
PNLH	DBM	$\{P_h^n\}$ - Nonlinear loads in modal transient problem.
PØ	DBM	$\{P_o\}$ - Partition of load vector.
PØI	DBM	$\{P_o^i\}$ - Partition of inertia relief load vector.
PØINT	IB	Eigenvalue analysis normalization option for eigenvectors - see EIGR, EIGC, EIGB cards.
PØINTAX	IB	Conical shell point used for data recovery.
PØØL	M	Pool tape used by file allocator.
PØUT$	M	Indicates restart with a printer output request.
PPF	DBM	Dynamic loads for frequency response.
PPHIG	DBM	Eigenvector components used to plot deformed shape. (D-3, D-5).
PPT	DBM	Linear dynamic loads for transient analysis.
PQDMEM	IB	Quadrilateral membrane element property definition card.
PQDMEM1	IB	Isoparametric quadrilateral membrane element property definition card.
PQDMEM2	IB	Quadrilateral membrane element property definition card.

PQDPLT	IB	Quadrilateral bending element property definition card.
PQUAD1	IB	General quadrilateral element property definition card.
PQUAD2	IB	Homogeneous quadrilateral element property definition card.
Preface	PH	Executive routines which are executed prior to the execution of the first module in a DMAP sequence. The Preface consists of the executive routines necessary to generate initial NASTRAN operational data and tables. The primary Preface routines are GNFIAT, XCSA, IFP1, XSØRT, IFP, IFP3, and XGPI.

PRESAX	IB	Defines static pressure loading for the conical shell element.
PRESPT	IB	Defines a point in a hydroelastic model for output purposes.
PRESSURE	IC	Request for output of pressure and displacement vector or eigenvector for a hydroelastic problem.
PRINT	IC	Selection of output media (PRINT or PUNCH).
Problem Tape	PH	A magnetic tape containing data necessary for NASTRAN problem restarts. A tape being generated is designated as the New Problem Tape (NPTP) and its content is largely controlled by the DMAP instruction CHKPNT. This same tape when used as input to a subsequent NASTRAN restart is designated as the Old Problem Tape (ØPTP).
PRØD	IB	Rod property definiton card.
PRØJECTIØN PLANE SEPARATIØN	IC	Separation of observer and projection plane for structure plots.
PRTMSG	FMS	Message generator.
PRTPARM	FMU	Prints DMAP diagnostic messages and parameter values.
PS	DBM	$\{P_s\}$ - Partition of static load vector.
PSDF	DBM	Power Spectral Density Function table.
PSDF	IC	Request for output of Power Spectral Density Function in Random Analysis (D-9, D-11).
PSDL	DBT	Power Spectral Density List.
Pseudo Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution but only affecting output data.
PSF	DBM	Partition of load vector for transient analysis.
PSHEAR	IB	Shear panel property definition card.
PST	DBM	Partition of linear load vector for transient analysis.
PTØRDRG	IB	Toroidal ring property definition card.
PRTBSC	IB	Basic bending triangular element property definition card.
PTRIA1	IB	General triangular element property definition card.
PTRIA2	IB	Homogeneous triangular element property definition card.
PTRMEM	IB	Triangular membrane element property definition card.
PTRPLT	IB	Triangular bending element property definition card.
PTUBE	IB	Tube property definition card.
PTWIST	IB	Twist panel property definition card.
PUBGV1	DBT	Displacement vector components used to plot deformed shape (D-4, D-5).
PUGV	DBT	Displacement vector components used to plot deformed shape (D-1, D-2).

PUGV1	DBT	Displacement components used to plot deformed shape (D-6).
PUNCH	IC	Output media request (PRINT or PUNCH).
PURGE	EM	DMAP statement which causes conditional purging of data blocks.
Purge	PH	A data block is said to be purged when it is flagged in the FIAT so that it will not be allocated to a physical file and so that modules attempting to access it will be signaled.
PVISC	IB	Viscous element property definition card.
PVT	PH	Parameter value table. The PVT contains BCD names and values of all parameters input by means of PARAM bulk data cards. It is generated by the preface module IFP and is written on the Problem Tape.

QBDY1	IB	Defines uniform heat flux into HBDY elements.
QBDY2	IB	Defines grid point heat flux into HBDY elements.
QBG	DBM	Single point forces of constraint in the Differential Stiffness Rigid Format (D-4).
QDMEM	IC	Requests structure plot for all QDMEM elements.
QDMEM1	IC	Requests structure plot for all QDMEM1 elements.
QDMEM2	IC	Requests structure plot for all QDMEM2 elements.
QDPLT	IC	Requests structure plot for all QDPLT elements.
QG	DBM	Constraint forces for all grid points.
QHBDY	IB	Defines thermal load for steady-state heat conduction.
QP	DBM	Constraint forces for all physical points.
QPC	DBM	Complex single point forces of constraint for all physical points.
QR	DBM	$\{q_r\}$ - Determinant support forces.
QS	DBM	$\{q_s\}$ - Single-point constraint forces.
QUAD1	IC	Requests structure plot for all QUAD1 elements.
QUAD2	IC	Requests structure plot for all QUAD2 elements.
QVECT	IB	Defines thermal vector flux from distant source.
QVØL	IB	Defines volume heat generation.

R	P	Parameter value used by MATGPR to print R-set matrices.
R1	IC	Request for X-Y plot of the first rotational component (UM-4.2).
R1IP	IC	Request for X-Y plot of the first rotational component - imaginary and phase angle (UM-4.2).
R1RM	IC	Request for X-Y plot of the first rotational component - real and magnitude (UM-4.2).
R2	IC	Request for X-Y plot of the second rotational component (UM-4.2).
R2IP	IC	Request for X-Y plot of the second rotational component - imaginary and phase angle (UM-4.2).
R2RM	IC	Request for X-Y plot of the second rotational component - real and magnitude (UM-4.2).
R3	IC	Request for X-Y plot of the third rotational component (UM-4.2).
R3IP	IC	Request for X-Y plot of the third rotational component - imaginary and phase angle (UM-4.2).
R3RM	IC	Request for X-Y plot of the third rotational component - real and magnitude (UM-4.2).
RADLIN	P	Controls linearization of radiation effects in transient heat transfer analysis.
RADLST	IB	List of radiation areas.
RADMTX	IB	Radiation exchange coefficients.
RANDØM	IC	Selects the RANDPS and RANDT cards to be used in random analysis.
RANDØM	FMS	Random response solution generator.
RANDPS	IB	Power spectral density specification.
RANDT1	IB	Autocorrelation function time lag.
RANDT2	IB	Autocorrelation function time lag.
RBMG1	FMS	Rigid body matrix generator - part 1.
RBMG2	FMS	Rigid body matrix generator - part 2.
RBMG3	FMS	Rigid body matrix generator - part 3.
RBMG4	FMS	Rigid body matrix generator - part 4.
READ	FMS	Real Eigenvalue Analysis - Displacement.
REAL	IC	Requests real and imaginary form of complex quantities.
REAL EIGENVALUES	IA	Selects rigid format for normal mode analysis.
REEL	IA	Term appearing on the checkpoint dictionary cards indicating the physical reel on which a data block appears.

Reentry Point	PH	The point in the DMAP sequence at which a problem terminated and hence the point at which it can be restarted (see Restart).
REGIØN	IC	Specifies portion of frame to be used for structure plot.
REIG	P	Parameter used in SDR2 to indicate Normal Mode Analysis (D-3).
REPCASE	IC	Allows another output request for the previous subcase (D-1, D-2).
REPEAT	P	Controls looping in Static Analysis (D-1, D-2).
REPEATD	P	Controls looping in Static Analysis with Differential Stiffness (D-4).
REPEATE	P	Controls looping in Complex Eigenvalue Analysis (D-7, D-10).
REPEATF	P	Controls looping in Frequency Response Analysis (D-8, D-11).
REPEATT	P	Controls looping in Transient Response Analysis (D-9, D-12).
REPT	EM	DMAP statement to conditionally repeat a loop.
RESPØNSE	IC	Request for X-Y plot of any response outputs from transient or frequency response analysis (D-8, D-9, D-11, D-12).
RESTART	IA	First control card of checkpoint dictionary. Contains identification of checkpoint tape.
Restart	PH	Initiating a NASTRAN problem solution at a place other than its logical beginning by utilizing an Old Problem Tape created during a previous run.
RFØRCE	IB	Rotational force definition card.
RFØRCE$	M	Indicates restart with change in rotational force.
RG	DBM	Multipoint constraint equations.
RIGHT TICS	IC	Request for tic marks to be plotter on right hand edge of frame for X-Y plots.
Rigid Format	PH	A fixed prestored DMAP sequence and its associated restart tables which perform a specific problem solution.
Rigid Format Switch	PH	A type of restart (see Restart) in which the problem is changed from one Rigid Format to another.
RINGAX	IB	Conical shell ring definition card.
RINGFL	IB	Hydroelastic axisymmetric point definition card.
RLØAD1	IB	Frequency response load set definition.
RLØAD2	IB	Frequency response load set definition.
RMG	FMH	Radiation matrix generator - generates $[R_{gg}]$.
RØD	IC	Requests structure plot for all RØD elements.
RUBLV	DBM	Residual vector - Differential Stiffness Rigid Format (D-4).

RULV	DBM	Residual vector for independent degrees of fredom.
RUØV	DBM	Residual vector for omitted degrees of freedom.
RXY	IC	Requests vector sum of X and Y deformation components for structure plot.
RXYZ	IC	Requests vector sum of X, Y and Z deformation components for structure plot.
RXZ	IC	Requests vector sum of X and Z deformation components for structure plot.
RYZ	IC	Requests vector sum of Y and Z deformation components for structure plot.

S	P	Parameter value used by MATGPR to print S-set matrices.
SACCE	IC	Abbrecivated form of SACCELERATIØN.
SACCELERATIØN	IC	Output request for solution set acceleration vector. (UM-2.3, 4.2)
SAVE	EM	DMAP statement which causes current value of parameter to be saved.
SAVE	M	Save data block for possible looping in DMAP sequence (see FILE).
SC	IC	Selects SC 4020 plotter.
Scalar Point	PH	A point which is defined on an SPØINT, CELAS1, CELAS2, CELAS3, CELAS4, CMASS1, CMASS2, CMASS3, CMASS4, CDAMP1, CDAMP2, CDAMP3, or CDAMP4 bulk data card. A scalar point has no geometrical coordinates and defines only one degree of freedom of the model.
SCALE	IC	Selects scale for structure plot.
SCE1	FMS	Single-point Constraint Eliminator.
SDAMP	IC	Modal structural damping table selection.
SDAMP$	M	Indicates restart with change in modal damping.
SDAMPING	IC	Selects table which defines damping as a function of frequency in modal formulation problems.
SDISP	IC	Abbreviated form of SDISPLACEMENT.
SDISPLACEMENT	IC	Output request for solution set displacement vector. (UM-2.3, 4.2)
SDR1	FMS	Stress Data Recovery - part 1.
SDR2	FMS	Stress Data Recovery - part 2.
SDR3	FMS	Stress Data Recovery - part 3.
SDRHT	FMH	Heat flux data recovery.
SECTAX	IB	Defines conical shell sector for data recovery.
SEEMAT	FMU	Prints pictorial representation of matrix showing location of nonzero elements.
SEM1	M	The NASTRAN Preface.
SEQEP	IB	Extra point resequencing.
SEQGP	IB	Grid or scalar point resequencing.
SET	IC	Definition of a set of elements, grid and/or scalar and/or extra points, frequencies, or times to be used in selecting output.
SETVAL	FMU	Parameter value initiator.
SHEAR	IC	Requests structure plot for all shear panel elements.
SIGMA	P	Defines Stefan-Boltzmann constant in heat transfer analysis.
SIL	DBT	Scalar Index List for all grid points.

SILD	DBT	Scalar Index List for all grid points and extra scalar points introduced for dynamic analysis.
SINE	IC	Conical shell request for sine set boundary conditions.
SINGLE	P	No single-point constraints.
SKIP BETWEEN FRAMES	IC	Request to insert blank frames on SC 4020 plotter for X-Y plots.
SKPMGG	P	Parameter used in statics to control execution of functional module SMA2.
SLBDY	IB	Defines list of points on interface between axisymmetric fluid and radial slots.
SLØAD	IB	Scalar point load definition.
SLT	DBT	Static Loads Table.
SMA1	FMS	Structural Matrix Assembler - phase 1 - generates stiffness matrix $[K_{gg}]$ and structural damping matrix $[K^4_{gg}]$.
SMA2	FMS	Structural Matrix Assembler - phase 2 - generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.
SMA3	FMS	Structural Matrix Assembler - phase 3 - add general element contributions to the stiffness matrix $[K_{gg}]$.
SMP1	FMS	Structural Matrix Partitioner - part 1.
SMP2	FMS	Structural Matrix Partitioner - part 2.
SMPYAD	FMM	Performs multiply-add matrix operation for up to five multiplications and one addition.
SØL	IA	Specifies which rigid format solution is to be used when APP is DISPLACEMENT.
Solution Points	PH	Points used in the formulation of the general K system.
SØLVE	FMM	Solves a set of linear algebraic equations.
SØRT1	IC	Output is sorted by frequency or time and then by external ID.
SØRT2	IC	Output is sorted by external ID and then by frequency or time.
SØRT3	M	Output is sorted by individual item or component and then by frequency or time.
SPC	IB	Single-point constraint and enforced deformation definition.
SPC	IC	Single-point constraint set selection.
SPC$	M	Indicates restart with change in single-point constraint set selection.
SPC1	IB	Single-point constraint definition.
SPCADD	IB	Single-point constraint set combination definition.
SPCAX	IB	Conical shell single-point constraint definition.

SPCF	IC	Abbreviated form of SPCFØRCE.
SPCFØRCE	IC	Single-point constraint force output request. (UM-2.3, 4.2)
Spill	PH	Secondary storage devices are used because there is insufficient main storage to perform a matrix calculation or a data processing operation.
SPØINT	IB	Scalar point definition card.
SSG1	FMS	Static Solution Generator - part 1.
SSG2	FMS	Static Solution Generator - part 2.
SSG3	FMS	Static Solution Generator - part 3.
SSG4	FMS	Static Solution Generator - part 4.
SSGHT	FMH	Solution generator for nonlinear heat transfer analysis.
STATIC	IC	Requests deformed structure plot for problem in Static Analysis.
STATICS	IA	Selects statics rigid format for heat transfer or structural analysis.
STATICS	P	Parameter used in SDR2 to indicate Static Analysis.
STEADY STATE	IA	Selects rigid format for nonlinear static heat transfer analysis.
STEREØSCØPIC	IC	Requests stereoscopic projections for structure plot.
STRESS	IC	Element stress output request. (UM-2.3, 4.2)
Structural Element	PH	One of the finite elements used to represent a part of a structure.
SUBCASE	IC	Subcase definition.
SUBCØM	IC	This subcase is a linear combination of previous subcases.
SUBSEQ	IC	Specifies coefficients for SUBCØM subcases.
SUBTITLE	IC	Output labeling data for printer output.
SUPAX	IB	Ficticious support for conical shell problem.
SUPØRT	IB	Ficticious support definition card.
SVECTØR	IC	Request for output of eigenvectors in the solution set (D-7, D-10) (UM-2.3, 4.2).
SVELØ	IC	Abbreviated form of SVELØCITY.
SVELØCITY	IC	Requests velocity output for solution set. (UM-2.3, 4.2)
SYM	IC	Symmetry subcase delimiter card.
SYMBØLS	IC	Requests symbols at grid points on structure plot.
SYMCØM	IC	Assembly of symmetry subcase delimiter card.
SYMSEQ	IC	Assembly value of symmetry combination card.

T1	IC	Request for X-Y plot of the first translational component (UM-4.2).
T1IP	IC	Request for X-Y plot of the first translational component - imaginary and phase angle (UM-4.2).
T1RM	IC	Request for X-Y plot of the first translational component - real and magnitude (UM-4.2).
T2	IC	Request for X-Y plot of the second translational component (UM-4.2).
T2IP	IC	Request for X-Y plot of the second translational component - imaginary and phase angle (UM-4.2).
T2RM	IC	Request for X-Y plot of the second translational component - real and magnitude (UM-4.2).
T3	IC	Request for X-Y plot of the third translational component (UM-4.2).
T3IP	IC	Request for X-Y plot of the third translational component - imaginary and phase angle (UM-4.2).
T3RM	IC	Request for X-Y plot of the third translational component - real and magnitude (UM-4.2).
TA1	FMS	Table Assembler.
TABDMP1	IB	Tabular structural damping function for modal formulation (D-10, D-11, D-12).
Table Data Block	PH	A data block which is in tabular form rather than matrix form.
TABLED1	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED2	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED3	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED4	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLEM1	IB	Material property tabular function.
TABLEM2	IB	Material property tabular function.
TABLEM3	IB	Material property tabular function.
TABLEM4	IB	Material property tabular function.
TABLES1	IB	Stress-dependent material tabular function for use in Piecewise Linear Analysis (D-6).
TABPCH	FMU	Punches selected tables on DTI bulk data cards.
TABPRT	FMU	Formats selected table data blocks for printing.
TABPT	FMU	Table printer.
TABRND1	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND2	IB	Tabular function for use in Random Analysis (D-8, D-11).

TABRND3	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND4	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABS	P	Defines absolute reference temperature in heat transfer analysis.
TALL EDGE TICS	IC	Request for plotting all edge tic marks on upper half frame for X-Y plots.
TAPE	M	Write data block on physical tape (see FILE).
TCURVE	IC	Curve title for X-Y plot.
TEMP	IB	Grid temperature definition card.
TEMPAX	IB	Temperature definition for conical shell problem.
TEMPD	IB	Grid default temperature definition card.
TEMPERATURE	IC	Selects the temperature set to be used in both material property calculation and thermal loading.
TEMPLD$	M	Indicates restart with change in thermal set for static loading.
TEMPMT$	M	Indicates restart with change in thermal set for material properties.
TEMPMX$	M	Indicates restart with change in thermal field with thermally dependent material properties.
TEMP(LØAD)	IC	Temperature set selection (applies to thermal load generation only).
TEMP(MAT)	IC	Temperature set selection (applies to material properties only).
TEMPP1	IB	Plate element temperature definition card.
TEMPP2	IB	Plate element temperature definition card.
TEMPP3	IB	Plate element temperature definition card.
TEMPRB	IB	One-dimensional element temperature definition.
TF	IB	Dynamic transfer function definition.
TF$	M	Indicates restart with change in transfer function set selection.
TFL	IC	Transfer function set selection.
TFPØØL	DBT	Transfer function pool.
THERMAL	IC	Request for output of temperature vector in thermal analysis (UM-2.3).
THRU	IC	Forms strings of values within set declarations.
TIC	IB	Transient Initial Condition set definition card.

TIME	IA	User time estimate for problem. This card is required in Executive Control Deck. Integer time value is in minutes.
TITLE	IC	Output labeling data for printer output.
TLEFT TICS	IC	Request for tic marks to be plotted on left hand edge of top half frame for X-Y plot.
TLØAD1	IB	Transient load set definition card.
TLØAD2	IB	Transient load set definition card.
Trailer	PH	A six word control block associated with a data block.
TRANRESP	P	Parameter used in SDR2 to indicate Transient Response Analysis (D-9, D-12).
TRANSIENT	IA	Selects rigid format for transient heat transfer analysis.
TRBSC	IC	Requests structure plot for all basic bending triangle elements.
TRD	FMS	Transient Response - Displacement.
TRHT	FMH	Integrates dynamic equation for heat transfer analysis.
TRIA1	IC	Requests structure plot for all TRIA1 elements.
TRIA2	IC	Requests structure plot for all TRIA2 elements.
TRIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of top half frame for X-Y plots.
TRL	DBT	Transient Response List.
TRLG	FMH	Generates dynamic heat flux loads.
TRMEM	IC	Requests structure plot for all triangular membrane elements.
TRNSP	FMM	Transpose functional module.
TRPLT	IC	Request structure plot for all TRPLT elements.
TSTEP	IB	Transient time steps for integration and output.
TSTEP	IC	Transient time step set selection.
TSTEP$	M	Indicates restart with change in transient time step set selection.
TUBE	IC	Requests structure plot for all TUBE elements.
TWIST	IC	Requests structure plot for all TWIST elements.
TYPE	IC	Indicates paper type for structure plots.

UBGV	DBM	Displacement vector for all grid points (D-4).
UBLL	DBM	$[U^b_{\ell\ell}]$ - Upper triangular factor of $[K^b_{\ell\ell}]$.
UBLV	DBM	Displacement solution vector (D-4).
UBØØV	DBM	Scalar multiple of UØØV in Differential Stiffness Rigid Format (D-4).
UDET	IB	Selects unsymmetric decomposition option for determinant method of real eigenvalue analysis.
UDV1T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT1. (D-9)
UDV2T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT2 (D-9).
UDVF	DBM	Displacement solution vector in a frequency response problem (D-8).
UDVT	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem (D-9).
UEVF	DBM	Displacement vector for extra points in a frequency response problem (D-11).
UEVT	DBM	Displacement vector for extra points in a transient response problem (D-12).
UGV	DBM	Displacement vector for all grid points (D-1, D-2, D-4, D-5).
UGV1	DBM	Successive sums of incremental displacement vectors. *Piecewise Linear Analysis Rigid Format only* (D-6).
UHVF	DBM	Modal frequency response solution vectors (D-11).
UHVT	DBM	Modal transient response solution vectors (D-12).
UINV	IB	Selects unsymmetric decomposition option for inverse power method of eigenvalue analysis.
ULL	DBM	$[U_{\ell\ell}]$ - Upper triangular factor of $[K_{\ell\ell}]$.
ULV	DBM	Displacement solution vector in static analyses (D-1, D-2, D-4, D-5).
UMERGE	FMM	Functional module to merge column matrices based on U-set.
UMF	IA	Requests User Master File as input source.
UMF	M	User Master File, a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
UMFEDIT	IA	Requests User Master File operational mode of NASTRAN.
Unmodified Restart	PH	Restarting (see Restart) a problem without changing any data, other than output requests, of the previous run.
Unpool	PH	Remove data block from Pool Tape and place on a file for use by a functional module.
UNSØRT	IC	Requests unsorted echo of Bulk Data Deck (ECHØ=UNSØRT).

UØØ	DBM	$[U_{oo}]$ - Upper triangular factor of $[K_{oo}]$.
UØØV	DBM	Partition of displacement solution vector.
UPARTN	FMM	Functional module to partition matrices based on U-set.
UPPER TICS	IC	Request for tic marks to be plotted on upper edge of frame for X-Y plot.
UPV	DBM	Transient solution vectors for all physical points.
UPVC	DBM	Frequency response solution vectors for all physical points.
USET	DBT	Displacement set definitions. (PM-1.7.3)
USETD	DBT	Displacement set definitions including extra scalar points introduced by dynamic analysis. (PM-1.7.3)
V	M	Used in parameter section of DMAP statement. Indicates that parameter is variable and may be changed by module. If changed value is to be used in subsequent DMAP instruction, it must be saved (see SAVE).
VANTAGE PØINT	IC	Location of observer for structure plot.
VDR	FMS	Vector Data Recovery.
VEC	FMU	Creates partitioning vector based on USET.
VECTØR	IC	Request for output of eigenvectors from real or complex eigenvalue analysis (D-3, D-5, D-7, D-10).
VECTØR	IC	Requests deformations on structure plot with vectors.
VELØ	IC	Abbreviated form of VELØCITY.
VELØCITY	IC	Output request statement for velocity vector. (UM-2.3, 4.2)
VFS	DBM	Partitioning vector for heat transfer analysis.
VIEW	IC	Rotation of object for structure plot.
VISC	IC	Request structure plot for all viscous damper element.
VPS	M	See XVPS.
W3	P	Pivotal frequency for uniform structure damping in the direct formulation of transient response problems (D-9).
W4	P	Pivotal frequency for element structural damping in the direct formulation of transient response problems (D-9).
WTMASS	P	Weight to mass conversion factor used in SMA2 and GPWG. Default value is 1.0.

X	IC	Requests X vector for deformed structure plot.
XAXIS	IC	Request for drawing of X-axis for X-Y plot.
XBAXIS	IC	Request for drawing of X-axis on bottom half frame for X-Y plot.
XBGRID LINES	IC	Request for drawing grid lines for X-axis on bottom half frame for X-Y plot.
XCSA	EM	Executive Control Section Analysis. The preface module which processes the Executive Control Deck and prepares the control file on the New Problem Tape.
XDIVISIØNS	IC	Request for division marking on X-axis.
XGPI	EM	Executive General Problem Initialization. The preface module whose principal function is to generate the ØSCAR. If the problem is a restart, XGPI initializes data blocks and named common blocks for proper restart.
XGRID LINES	IC	Request for grid lines to be drawn on X-axis for X-Y plots.
XINTERCEPT	IC	Specifies intercept of Y-axis on X-axis.
XLØG	IC	Request for logarithmic scales in X-direction.
XMAX	IC	Do not plot points whose X value lies above this value.
XMIN	IC	Do not plot points whose X value lies below this value.
XPAPER	IC	Specifies length of paper in X-direction for table plotter.
XSFA	EM	Executive Segment File Allocator - the administrative manager of data blocks for NASTRAN.
XSØRT	EM	Executive sort routine - the preface module which reads and sorts the Bulk Data Deck and writes the sorted Bulk Data Deck on the New Problem Tape.
XTAXIS	IC	Request for drawing of X-axis on top half frame.
XTGRID LINES	IC	Request for drawing of grid lines on top half frame.
XTITLE	IC	X-axis title for X-Y plots.
XVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
XVPS	M	Variable Parameter Set Table. Executive table needed for restart. (PM-2.4)
XY	IC	Requests X and Y vectors for deformed structure plot.
XYCDB	DBT	SØRT3 type output requests (XYPLØTTER, XYPRINTER, Random Request).
XYØUT	IC	Request to generate X-Y plots.
XYØUT$	M	Indicates restart with an X-Y plot request.
XYPEAK	IC	Request to print the maximum and minimum values of the specified response.

XYPLØT	FMS	X-Y plot generator.
XYPLØT	IC	Request to generate X-Y plots.
XYPLTF	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTFA	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTR	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTT	DBT	XYPLØT input data block. (D-9, D-12)
XYPLTTA	DBT	XYPLØT input data block. (D-9, D-12)
XYPRINT	IC	Request to tabulate XY pairs on the printer.
XYPRNPLT	FMU	Dummy output module.
XYPUNCH	IC	Request to punch XY pairs.
XYTRAN	FMS	XY output translator.
XYZ	IC	Requests X, Y and Z vectors for deformed structure plot.
XZ	IC	Requests X and Z vectors for deformed structure plot.

Y	IC	Requests Y vector for deformed structure plot.
Y	M	Used in parameter section of DMAP statement. Indicates that parameter may be given an initial value with a PARAM bulk data card.
YAXIS	IC	Request for drawing of Y-axis.
YBDIVISIØNS	IC	Request for division marking on Y-axis of lower half frame.
YBGRID LINES	IC	Request for grid lines to be drawn on Y-axis of lower half frame.
YBINTERCEPT	IC	Specifies intercept of X-axis on Y-axis on lower half frame.
YBLØG	IC	Request for logarithmic scales in Y-direction on lower half frame.
YBMAX	IC	Do not plot points whose Y value lies above this value for lower half frame.
YBMIN	IC	Do not plot points whose Y value lies below this value for lower half frame.
YBS	DBM	Scalar multiple of YS matrix. Used in Differential Stiffness Rigid Format only. (D-4).
YBTITLE	IC	Y-axis title on lower half frame.
YBVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YDIVISIØNS	IC	Request for division marking on Y-axis.
YES	IA	Option used on CHKPNT card, indicates that checkpoint is desired.
YGRID LINES	IC	Request for grid lines to be drawn on Y-axis.
YINTERCEPT	IC	Specifies intercept of X-axis on Y-axis.
YLØG	IC	Request for logarithmic scales in Y-direction.
YMAX	IC	Do not plot points whose Y value lies above this value.
YMIN	IC	Do not plot points whose Y value lies below this value.
YPAPER	IC	Specifies length of paper in Y-direction for table plotter.
YS	DBM	$\{Y_s\}$ - Constrained displacement vector.
YTDIVISIØNS	IC	Request for division marking on Y-axis for upper half frame.
YTGRID LINES	IC	Request for grid lines to be drawn on Y-axis for upper half frame.
YTINTERCEPT	IC	Specifies intercept of X-axis on Y-axis for upper half frame.
YTITLE	IC	Y-axis title.
YTLØG	IC	Request for logarithmic scales in Y-direction for upper half frame.

YTMAX	IC	Do not plot points whose Y value lies above this value for upper half frame.
YTMIN	IC	Do not plot points whose Y value lies below this value for upper half frame.
YTITLE	IC	Y-axis title for upper half frame.
YTVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YZ	IC	Requests Y and Z vectors for deformed structure plot.
Z	IC	Requests Z vector for deformed structure plot.